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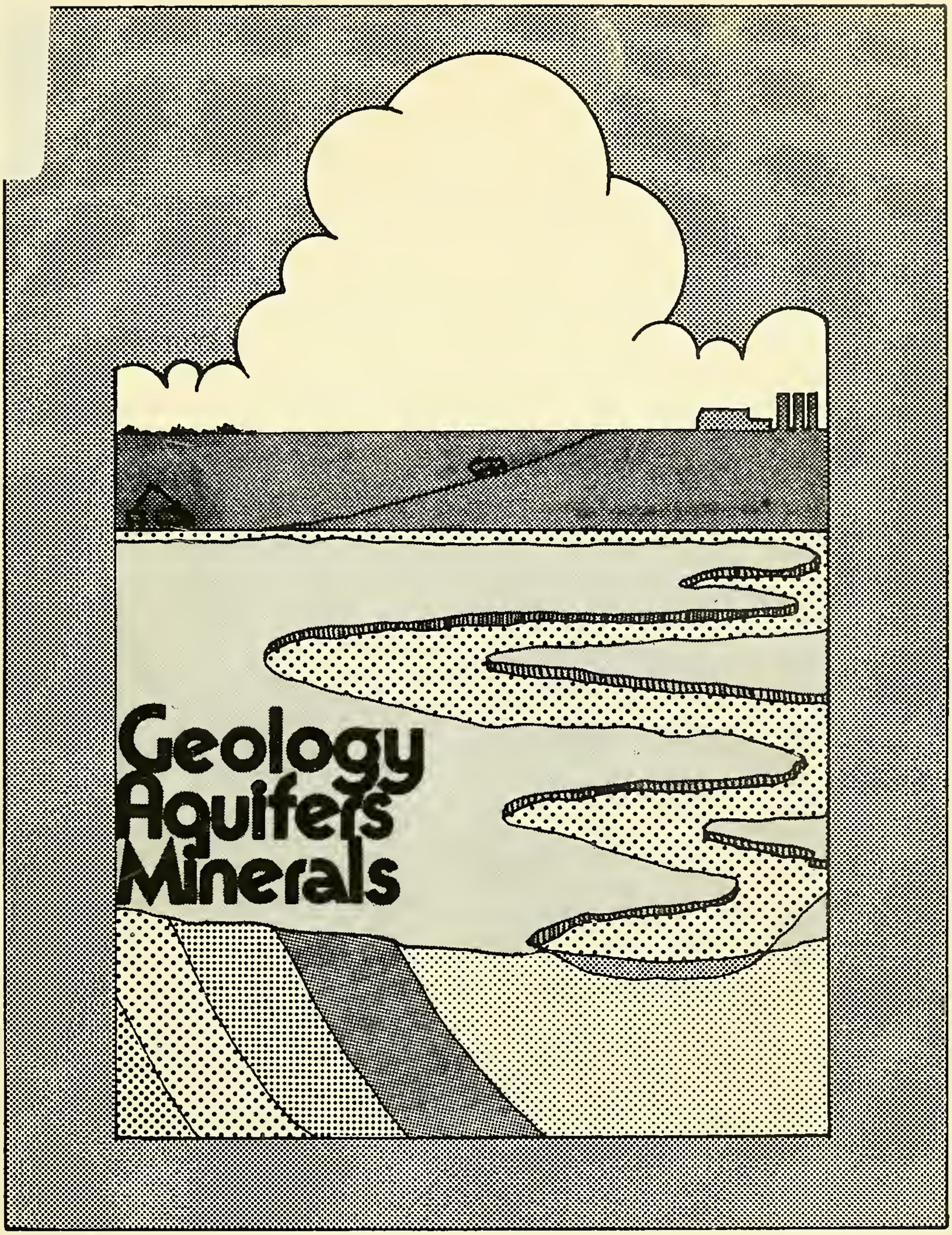

Geology Aquifers Minerals

technical series january 1974

GENERALIZED LAND USE PLAN

Maryland Department of State Planning

HONORABLE MARVIN MANDEL
GOVERNOR OF THE STATE OF MARYLAND

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The MAP series to be used in conjunction with this publication, may be found in the Maryland Room Map Index, under:

Maryland. Department of State Planning. Engineering, geology and aquifer formation map -- name of county -- 1963/74.

also

Maryland. Department of State Planning. Minerals maps -- name of county -- 1963/74.

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six month terms)

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See p. 187 for map numbers

Maryland Department of State Planning
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GEOLOGY, AQUIFERS, MINERALS

Errata

p. 8	MMC should read MMc
p. 10	Table Z should read Table 2
p. 12-13	Balto. Co. 04 should read Balto. Co. 03
p. 19	LMMg " " lMMg
p. 22	2USsg " " 2UScsg
p. 27	11Ussc " " 11USsc
	12Uss " " 12USs
	13Uss " " 13USs
	14Uss " " 14USs
	15Usgs " " 15USgs
p. 48	The 2MMp Loudoun formation does not occur on the county map, even though the formation was fully defined in the original survey source material. 6Sc should read 6Sd The following entry was omitted: 7Shsl Waynesboro formation (2207) Largely red shale, with subordinate interbeds of sandstone and dense limestone.
p. 160	01 should be added to the Calvert County and St. Mary's County columns for the Piney Point formation.

GEOLOGY, AQUIFERS, MINERALS

Errata - II

p. 68 - 71	The number code for Carroll County should read 07 -- not 06--
p. 72 - 75	The number code for Cecil Co. should read 08 -- not 07 --
p. 85	1203 should read 1202
	1204 " " 1203 (1st 1204)
p. 179	code 07 is missing should read clay and shale pit active black dot 07

Notice no Talbot County minerals map has been produced since no deposits have been located.

TITLE· Geology, Aquifers, and Minerals Technical Report

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ABSTRACT

This publication, prepared as part of the land capability analysis of the Maryland Generalized Land Use Plan, describes the major geologic formations, aquifer systems and mineral resources in the State of Maryland. The capability parameters for each of these topics are described in terms of their ability to support various land uses. This manual has been designed for use with three sets of county maps, locating the various geology, aquifer and mineral areas in the State; it explains in detail how available date on these topics were converted for use in the Maryland Generalized Land Use Plan.

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PREFACE

The legislation creating the Maryland Department of State Planning (Articles 41 and 88C, Annotated Code of Maryland) assigns to the Department the responsibility of preparing and keeping up-to-date "a plan or plans for the development of the State, which plan or plans collectively shall be known as the State Development Plan."

Based on its responsibility as stated above, numerous special studies and projects have been or are being completed by the Department of State Planning, including a study of the Chesapeake Bay, a study of State Wetlands, an Outdoor Recreation and Open Space Plan, and a Historic Preservation Plan.

In addition to the above studies, the Department of State Planning is currently preparing a State Development Plan; this plan aims to provide a coordinated basis to guide the future development of the State in such a way as to assure the general welfare and prosperity of the people of Maryland. It is to be based on studies of social, economic, and physical conditions and trends in the State and will examine these conditions and trends with the intention of establishing objectives within a goals-oriented framework. The plan as presently defined has two major elements, the Land Use Plan and the Human Resources Plan, in order to emphasize equally the best use of the State's physical resources and the well-being of its citizens.

The Land Use Plan will describe desirable general patterns for the development of land related facilities and services, as well as suggest policies for the management of the State's natural resources. It will include:

1. a statement of the goals, policies, standards and criteria upon which the plan is based; and
2. recommendations for the most desirable general pattern of land use within the State;
3. recommendations for the major transportation facilities and services within the State which are consistent with and supportive of the Generalized Land Use Plan;
4. recommendations for the major public facilities and services which are consistent with and supportive of the Generalized Land Use plan;
5. recommendations for the actions required to implement the plan.

The methodology utilized for the development of the land use plan was based upon four assumptions.

1. that the State Land Use Plan sets the State Policy for utilization of its land resources, facilities, and services.
2. that the plan is based upon an evaluation of the State's characteristics, land resources, and citizens' needs and aspirations.
3. that priority selection must take place.
4. that the plan and process can have a substantial impact upon the future quality of life and growth of the state.

There are several methodological phases necessary to prepare the Generalized Land Use Plan. They are:

1. preliminary research and analysis.

2. capability analysis.
3. suitability analysis.
4. goal and policy formulation.
5. preliminary developments of land use plan alternatives.
6. review of alternatives and final plan selection.

The capability/suitability phases form the heart of the plan's methodology. They provide the information on which much of the other work is based. Within the context of the Land Use Plan, capability refers to the ability of land to support particular uses based upon the relevant physical characteristics of the land. Capability analysis involves the selection of those factors most important for specific land uses, and then by the consideration of physical constructs the identification of areas of the State which can best support those types of land use. The Department of State Planning has outlined the following parameters for the capability analysis:

1. percentage of slope as an indicator of topography
2. floodplain delineation
3. soil characteristics
   a. agricultural productivity
   b. erosion susceptibility
   c. permeability
   d. depth to bedrock
   e. depth to water table
   f. stability
4. wildlife and fish habitats
5. forests by type
6. geological setting
   a. type
   b. hardness
   c. stability of cuts
   d. durability
7. aquifers
8. mineral resources
9. unique natural features and scenic areas
10. surface water quality

On the other hand suitability refers to those variables, in addition to basic capability, which relate directly to private and public expenditures or facilities that are programmed over long periods and which can be utilized to determine areas equally capable of supporting various activities. The following factors are to be considered in the plan for the purposes of suitability analysis:

1. existing and proposed land use
2. existing and proposed sewer and water service
3. existing State and Federally owned lands
4. existing and proposed transportation facilities
   a. airports
   b. road intersections
   c. pipe line right of ways
   d. high voltage electric line right of ways
   e. ship channels
   f. rapid transit right of ways
5. existing local and regional plans
6. historical structures or areas.

For reasons of economy, no new data was gathered in the preparation of the capability and suitability analyses of the Land Use Plan. Instead, existing information was converted into suitable formats and within this constraint, every effort was made to interrelate, balance, update, translate and transform the diverse data sources. Of necessity, then, ad hoc decisions had to be made by the Department of State Planning regarding the selection and analyses of data, based upon information available at that point in time.

This manual is part of a series produced in conjunction with the preparation of the capability and suitability analyses of the Land Use Plan. These manual have been prepared so that the major assumptions and techniques utilized in the development of the data base are available to those not directly responsible for its production in the hopes that they will be able to determine if the data base may be of use to them, to understand the limitations and qualifications of the date, and to suggest improvements. In addition, the Department of State Planning is concerned that too often general plans have been developed and adopted for a particular area, but have not been accepted by its citizens because the plan methodology could not be understood. In the public sphere, perhaps more than in any other, an understanding of the means of a plan is as important as that of the ends; both must receive approval if any plan is to be given a sufficient level of credulity so as to make it truly effective. It is to foster such an understanding, then, that these manuals are also aimed.

Geology

I. GEOLOGY

A. Introduction

When considering the earth's geology (i.e. the physical character of the earth's land masses), one is apt to conjure up two conflicting images. On the one hand, we are aware of cataclysmic events like volcanoes or earthquakes and also long-term processes like continental shifts that dramatically alter the earth's geology and reflect its basic instability. On the other hand, we are not inclined to consider the earth's geology as affecting our daily environment. We generally tend to think of the earth as a static, stable mass that, in its natural state, exists unchanged for extremely long periods of time; even man's activities seem to alter only slightly the surface of the land and the rock structure beneath it.

Upon closer investigation, however, this second assumption proves to be false. Even excluding massive land convulsions and processes that occur over millions of years, one begins to see that the land as we know it is not so stable as it initially appears. In Maryland, for example, there are numerous forces which constantly interact with the surface of the earth, causing it to move and change. An obvious instance of this is the effect of surface water upon the land; this phenomenon occurs in the Chesapeake Bay where several islands are disappearing due to the action of waves and the basic instability of the land. This process is not limited to islands either; on the contrary, erosion of the land by rainfall transports a substantial amount of land to the ocean each year, thereby altering the geology not only of the inland area that has been eroded, but also of the area where sediment is deposited.

However, even if one agrees that water is, in fact, constantly moving the land around, the land itself is not moving and it is something that can be accommodated by engineering techniques; the basic stability of the land still seems unquestionable. Or is it?

Driving down a highway that has been cut through a hill, one frequently sees "Falling Rocks" sings or, occasionally actual fallen rocks at the foot of the cut. It is apparent, then, that the rocks move, that the geologic structure shifts position. This movement is caused by a basic instability in some rock structures; human activity on these rocks only aggravates their tendency to shift position. If development is not engineered properly, geologic movement can occur on a large scale, endangering property and lives. Thus, information about the State's geology is a necessary part of any land use plan. Such information is of value to developers for it describes where, based on optimum geologic conditions need to be stabilized through engineering techniques for such development to be safe.

Thus, the interpretation of Maryland's geology has been done from a capability for use viewpoint, that is, to determine the ability of a particular rock type or area to support certain activities. The need to know how the ground beneath a proposed building site will respond to blasting or digging is essential, for if the stability of the ground beneath a building site is poor, it could slide down a hill, as many homes have in California.

A lack of knowledge as to where limestones and marbles occure provides another excellent example of the problems that can arise when the bedrock geology is not studied prior to a project decision. Sinkholes can develop in the surface of limestone beds, leaving gaping holes that are difficult to fill and impossible to prevent. Excavation problems vary considerable due to the irregualr variation in depth to bedrock surface caused by weathering and solution activities on the limestone. Solution cavities may cause leakage of septic effluent into the groun water system (aquifer) and pollute local streams and ponds. Cavernous limestone will cause leakage if a dam or reservoir is build astride it.

This report attempts to provide the general information necessary to make statements about land use capabilities as they are influenced by geologic materials; also, in that the presence of aquifers and minerals are related to geologic structure, this report will also relate land use capabilities to these two factors.

This manual is designed to be used with three sets of county maps, respectively depicting a) the locations of various geologic formations in Maryland; b) the distribution of aquifer formations in the State; and c) the distribution of various mineral commodities in the State. These maps, produced as part of the capability analysis of the Maryland Generalized Land Use Plan, were base on maps and accompanying engineering geology tables produced in 1965. The geologic data from this earlier map set was expanded and interrelated with other available data to provide the necessary information. Data bout all three of these variables (i.e. geology, aquifers and minerals) was then used to generate the three sets of maps to be used with this manual.

Maps have been drawn on the scale of 1:63,360 (1 inch=1 mile), one should be cautioned that this mapping scale and the level of data applicability are appropriate for the purposes of the Maryland Generalized Land Use Plan. If detailed information on the specific characteristics of a formation is necessary, more on site investigation and more detailed mapping will be needed. Unless more detailed mapping on a larger scale is done, such as the $7\frac{1}{2}$ minute topographic quadrangle maps with a scale of $2\frac{1}{4}$ inches to the mile, it will be very difficult to pinpoint specific localities of geologic formations; to do so requires a detailed series of chemical and physical tests.

B. Geologic Regions in Maryland

Maryland has a highly complex and extremely variable geologic structure. The structural differences from one area and one formation to the next indicate that problems may result if certain projects are undertaken, since a method of construction in one area my not work in another. A detailed study of geologic capabilities is presented to aid in development plans.

Maryland is divided into five distinct physiographic regions, each determined on the basis of similar appearance and structure: The Coastal Plain Area, Piedmont Area, Trissic Area, Valley and Ridge Area, and Allegany Mountain Area. They are illustrated on Figure 1.

1. Coastal Plain Area

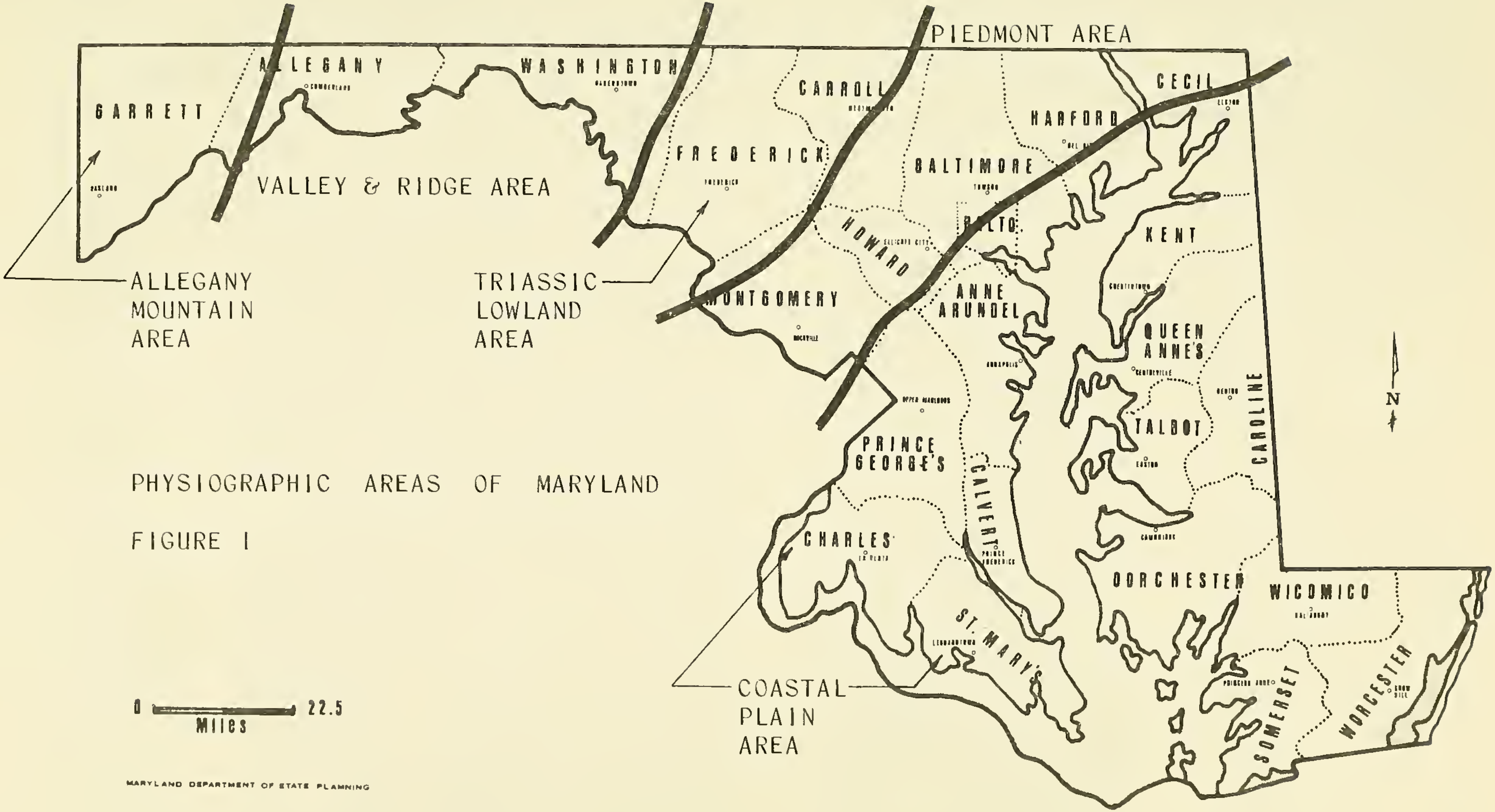
The formation exposed along the Coastal Plain, lying along the Atlantic Coast, are relatively young compared to the areas further west. Many of them have not been appreciably consolidated or cemented into solid bedrock formations, and thus offer little or no difficulty in excavating. Locally, some of these formations include beds of sand or gravel that have become cemented by limonite, producing relatively hard layers intercalated with soft beds of silt or clay. In general, the older strata of the Coastal Plain series have been more firmly consolidated than the younger beds.

Uplift along the Coastal Plain has occurred without appreciable folding; thus the belts of outcrops of the successive strata may be comparatively wide and occupy broad areas. Furthermore, since the Formations are inclined seaward at angles of very few degrees, relatively thin strata may be exposed along relatively wide belts. Moreover, successively older strata will be exposed further inland. This pattern of distribution of outcrops is reavealed by the geologic maps of the Coastal Plain counties.

2. Piedmont Area

The beveled edges of the older Coastal Plain formations which are to the west rest upon deeply eroded crystalline metamorphic and igneous rocks that are exposed throughout the Piedmont Area. These formations include a great variety of geologically ancient rocks of both igneous and sedimentary origin that have been greatly contorted and sheared, and recrystallized into metamorphic rocks -- schists, gneisses, quartzites, marbles, and serpentines. Most of these formations display pronounced planes of layering (foliation) that are inclined at various degrees, but are generally steep. Many of them present problems in excavation and instability, where the planes of foliation dip toward excavations. In general, these rocks are comparatively very hard. For the most part, these metamorphosed formations also outcrop in roughly parallel belts, which because of shearing and intense folding, present a much less regular pattern of outcrop belts than do similar formations elsewhere in the State. Because of the highly complicated folding, it is more difficult to trace individual formations, determine lithologic boundaries, and correlate metamorphic formations from place to place. Consequently, the boundaries of the Piedmont Area indicated on geologic maps are more generalized than those of other areas. Also, interpretations of engineering properties and behavior of these formations are proportionately less specific.

The Piedmont area has been subjected to greatly prolonged weathering and erosion through many geologic periods. As a consequence, both hard and soft rocks have been eroded to a general plain, now dissected by fully



PHYSIOGRAPHIC AREAS OF MARYLAND

FIGURE I

MARYLAND DEPARTMENT OF STATE PLANNING

integrated drainage systems and marked by pronounced, but only moderately deep, valleys and by intervening broadly rounded summit areas. The decay of rocks by weathering processes is comparatively deep. This has resulted in a general soil zone that, though varying in thickness, is measured by several tens of feet in some areas. Such a soil zone, of course, obscures the boundaries of bedrock formations and makes interpretations of their nature and distribution correspondingly less definite than in other areas. Interpretations of rock formations as indicated on the geologic and materials maps must be understood and used with this condition clearly in mind. The maps are, therefore, general guides of the entire area rather than guides for details of specific, small areas.

3. Triassic Lowland Area

Between the Piedmont area of crystalline rocks and the Blue Ridge, and almost entirely within Frederick County, lies a comparatively small, irregular area underlain by relatively soft, red sandstone and shales of older geologic age than the formations in the bordering areas. These sedimentary rocks are covered by a thick regolith of red sandy and clayey soils. The Triassic Lowland area is part of a continuous belt that extends northeasterly into Pennsylvania and New Jersey, and southwesterly into Virginia. Here the soils are easily excavated but, in themselves, provide relatively little material of engineering value, except for sills and dikes of trap rocks. The presence of such trap rock bodies, where not exposed, is commonly indicated by rounded boulders that have weathered to a deep brown color. The fresh rock is exceptionally good for aggregate and other crushed stone uses.

4. Valley and Ridge Area

Allegany and Washington Counties and adjacent parts of Frederick and Garrett Counties like within the Valley and Ridge province of the Appalachian Mountains. Here the thick series of underlying sedimentary formations have been folded into a succession of anticlines and synclines; the beds dip at various angles and are exposed along parallel belts of outcrops. Deep erosion has etched the region so that exposed edges of the harder formations (chiefly sandstone) form ridges; many of the intervening valleys are underlain by softer, soluble limestones or soft shales. Because of the long, continued, deep weathering of the less resistent limestones and shales, the valley floors are commonly covered by a thick residual regolith composed largely of clays and generally colored red or brown by iron minerals. Consequently, geologic boundaries of the valleys are more interpretative that boundaries of formations that comprise the ridges.

Formations in this area are almost entirely sedimentary (conglomerate, sandstone, siltstone, shale, limestone, and dolostone). Unlike the older formations in the Piedmont area, they are not metamorphosed into schists, gneisses, slates and marbles, and have undergone less deformation. Consequently, where boundaries are established or indicated, they are more regular and more easily projected or interpretated. The formations are also lithologically more uniform for long distances than in the Piedmont area.

5. Allegany Mountain Area

The extreme western part of the State, comprising Garrett County and the western part of Allegany County, lies in an area of broad anticlines and synclines in which the strata are much less steeply folded than those of the Valley and Ridge area; they dip at low angles and in many places are essentially horizontal. Here are exposed a varied assortment of sedimentary strata consisting of conglomerates, sandstones, shales, limestones, and interrelated beds of coal. Many of these sedimentary formations are only moderately hard. Most of the area presents no problem in excavating, but the softer shales in places present some difficulty in maintaining stable cut slopes.

Formation boundaries are, in general, easily followed in this area. Belts of outcrop are comparatively wide because of the small angles of dip.

C. Data Inputs for Geology

1. Data Sources

The Engineering Geology portion of this manual has been developed primarily from the Engineering Geology Tables of the Maryland Engineering Soil Study, which was completed in June, 1965. The county maps which accompanied that study were modified for use as the base maps of this effort. Dr. Johnathan Edwards was consulted at the Maryland Geological Survey concerning the suitability of this data for the geology analysis input to the Maryland Generalized Land Use Plan. In addition, he assisted the Department of State Planning staff in extending the applicability of this basic geological information to the aquifer and mineral portions that follow.

The majority of the data compiled for the 1965 report came from county geologic reports and maps produced up to that time by the Maryland Geological Survey. Additional maps and reports of the U.S. Geological Survey were also utilized. However, in both bases the basic geological data was recast in terms of engineering applications by the Civil Engineering Department of the University of Maryland, using Maryland Highway maps as a base. It is important to note that field work was not performed specifically for the 1965 study nor was it performed for the Land Use Plan effort. Also, the geologic formation boundaries were accepted as delineated on the material supplied in 1965.

A copy of the original geology map key and a segment of one of the maps using this key is included here in Figure 2 for reference. Full sets of these maps are available from the Map Distribution Center at Brooklandville and the original publication can be obtained through the Maryland Geological Survey.

In the preparation of the engineering geology maps, it is inevitable that the details of lithologic interpretation and the placing of formation boundaries reflected the various degrees of accuracy of the original maps. Also, the conversion of geologic descriptions and data into Engineering Materials terminology originally involved the various personal equations and interpretations of the geologists who prepared those original engineering maps. This conversion doubtlessly has led to some indefiniteness and promoted some generalizations where more exact and specific descriptions might be needed.

More specifically, these original engineering maps were primarily lithologic rather than formational. In many instances several geologic formations were mapped together because of similarities in lithology and engineering behavior. Thus, some of the boundaries of the basic geologic units were eliminated, because the purely stratigraphic boundaries of the original maps would have provided no useful discrimination, and would have led to some confusion.

The original county geologic maps were prepared over many years, during which formational names and correlations were changed from county to county. The Civil Engineering Department of the University of Maryland retained the correlations and nomenclature of the original maps, in general, so that confusion might be avoided when the earlier geologic map and the engineering geology map of a particular county are compared. It is felt that with these limitations in mind, these maps will be a useful guide.

FIGURE 2

Original Engineering Geology Map Legend

IGNEOUS ROCKS (1)

1a	Gabbro and Metagabbro	1i	Intrusives
1b	Basic Rock	1l	Lava (rhyolite, tuff, breccia)
1bb	Basic Breccia	1qd	Quartz Diorite
1d	Diabase	1t	Tonalite
1g	Granite	1v	Basic and Acid Volcanic
1gd	Granodiorite	1y	Pyroxenite

SEDIMENTARY ROCKS AND FORMATIONS (S)

Sa	Agrillite	Sl	Limestone
Sd	Dolomite	Ss	Sandstone
Sh	Shale		

UNCONSOLIDATED SEDIMENTARY FORMATIONS (US)

USc	Clay	USs	Sand
USg	Gravel		

METAMORPHIC ROCKS (MM)

MMC	Conglomerate	MMmr	Metarhyolite
MMg	Gneiss	MMp	Phyllite
MMl	Slate	MMq	Quartzite
MMm	Marble	MMs	Schist
MMmb	Metabasalt	MMse	Serpentine

ALLUVIAL DEPOSITS (A)

AF	Alluvial Cones (Mountain Wash)
AR	Alluvial Recent
AT	Alluvial Terrace

Note: 1. Number preceding the symbol is a reference number use to identify occurrence of similar materials.

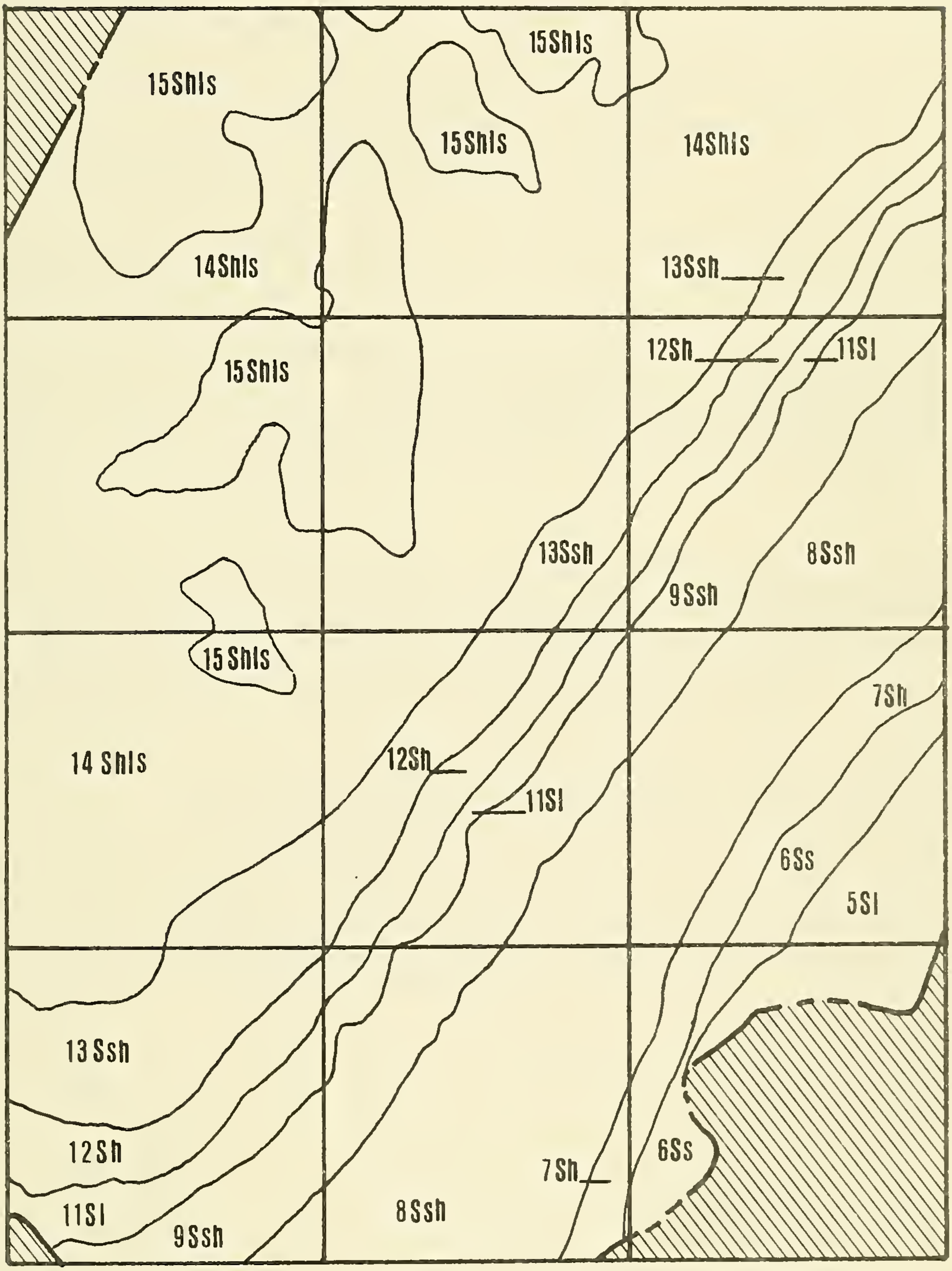
2. Lower case letters indicate the Specific types of rock or material and are arranged in the order of quantity present--unconsolidated sedimentary and sedimentary materials only.

3. Symbols shown: 2MMp/4MMs indicates occurence of both materials in the map unit.

4. Symbols shown: $\frac{\text{2MMp}}{\text{4MMs}}$ indicate that 2 MMp is underlain by 4MMs.

Figure 2 (cont.)

Segment of Engineering Geology Map



2. Data Conversion

Once the maps and text were determined to be suitable for the study, a method was developed to convert the base maps into a numerical format suitable for computer encoding.

The number and letter combinations used were changed into four digit number series by masking the letter groups and adding a different two digit prefix for each county to the numbers used to identify the occurrence of similar materials. The 23 counties of the state and the City of Baltimore were simply placed in alphabetical order and assigned numbers 01 through 24. The ability to determine similar formations in different counties was, unfortunately, lost as a result. However this transformation technique was chosen because it was the simplest and quickest.

During this operation there were no other changes made in the original base maps. An example of an engineering geology map converted to computer encoding is shown in Figure 3.

These number combinations, found on Figure 3, are utilized in the remainder of this section as well as in the aquifer and mineral sections. The following tables make use of the numbering system while showing the formation name for reference purposes; however, in Table 1 the four digit number issplit into two parts. Every effort was made to utilize the numbering system as a unifying device.

3. Data Interpretation

You will recall that the data presented in the following tables was derived from the Engineering Geology tables and maps prepared by the Civil Engineering School of the University of Maryland in 1965, and modified by the Department of State Planning staff with the assistance of the Maryland Geological Survey for the Maryland Generalized Land Use Plan. The maps should be used in conjunction with the following tables:

Table 1 locates the various formations by geologic name, key number and county of occurence. It should be noted that some minor formations are omitted from this table, although they are listed in table Z.

Table 2 lists the geologic characteristics and descriptions of each formation by county.

Table 3 lists the various engineering capabilities of each formation on the basis of a good, fair, poor or hard, medium, etc. development potential.

Figure 3

Segment of Engineering Geology Map Converted for Computer Encoding

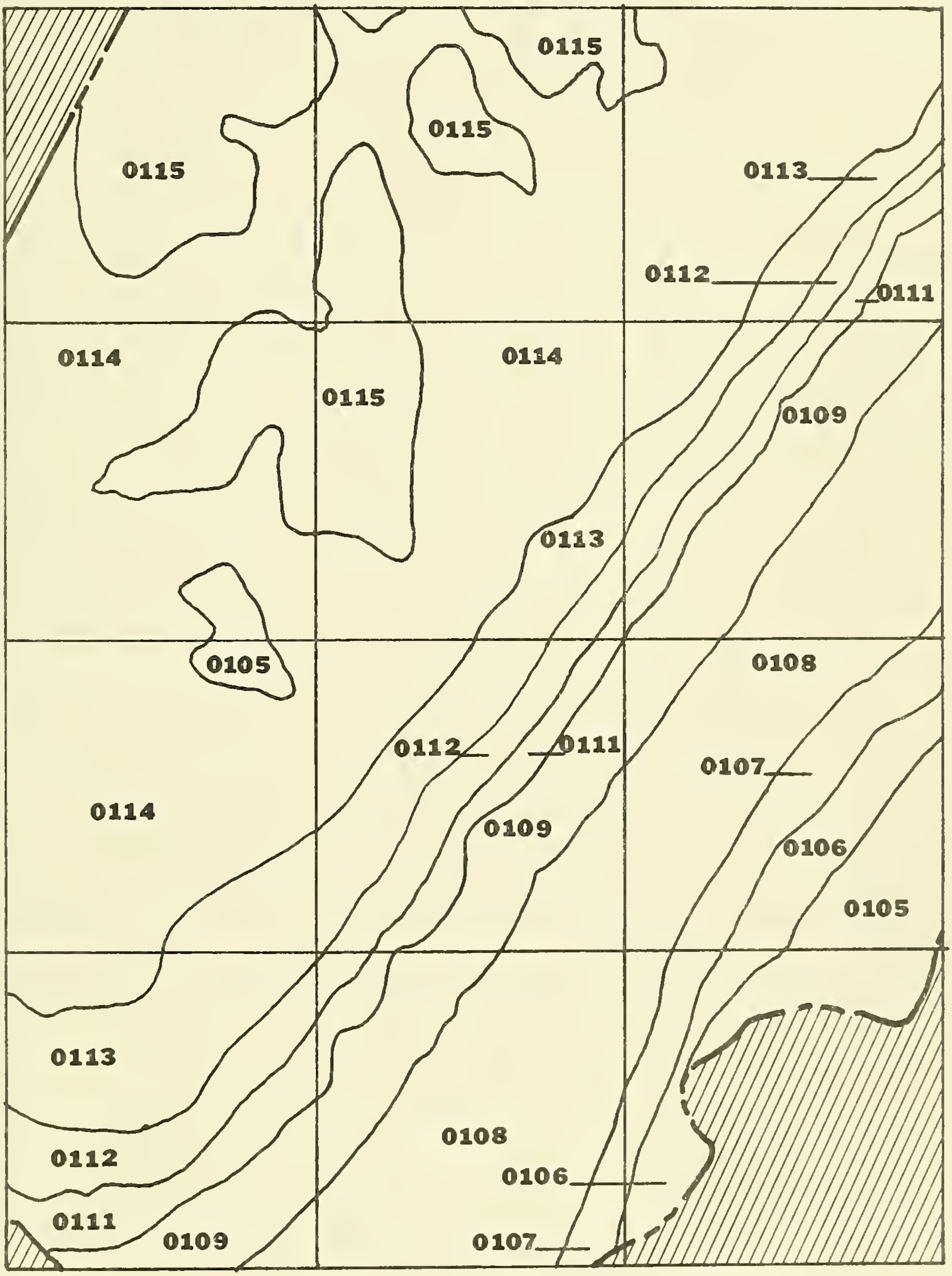


Table 1: Location of Geologic Formations by Name, Key Number and County

COASTAL PLAIN

FORMATION	Anne Arundel (02)	Baltimore (04)	Calvert (05)	Caroline (06)	Cecil (08)	Charles (09)	Dorchester (10)	Harford (13)	Howard (14)	Kent (15)	Montgomery (16)	Prince George's (17)	Queen Anne's (18)	St. Mary's (19)	Somerset (20)	Talbot (21)	Wicomico (23)	Worcester (24)
Patuxent	01	14	--	--	10/08	--	--	11	14	--	12-	01	--	--	--	--	--	--
Arundel	02	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Patapsco	03	15	--	--	10/09	--	--	12	--	--	13	02	--	--	--	--	--	--
Raritan	04	17	--	--	11	--	--	--	--	01	--	--	--	--	--	--	--	--
Magothy	04	--	--	--	--	--	--	--	--	01	--	--	--	--	--	--	--	--
Matawan	05	--	--	--	--	--	--	--	--	01	--	--	--	--	--	--	--	--
Monmouth	05	--	--	--	12	--	--	--	--	02	--	04	--	--	--	--	--	--
Brightseat	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aquia	06	--	--	--	13	--	--	--	--	02	--	05	01	--	--	--	--	--
Nanjemoy	06	--	01	--	--	01	--	--	--	--	--	06	--	--	--	--	--	--
Piney Point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chesapeake Grp	--	--	01	--	--	--	--	--	--	--	--	07	--	01	--	--	--	--
Calvert	07	--	--	01	--	01	--	--	--	03	--	--	01	01	--	01	--	--
Choptank	--	--	--	01	--	--	--	--	--	--	--	--	--	--	--	01	--	--
St. Mary's	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Yorktowne	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brandywine	08	18	--	--	14	02	--	13	--	--	--	08	--	02	--	--	--	--
Columbia Grp.	--	--	02	--	--	03	01	--	--	--	--	--	--	03	01	--	01	01
Bryn Mawr	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sunderland	09	18	--	--	15	--	--	14	--	--	--	09	--	--	--	--	--	--
Wicomico	09	--	--	02-	15	--	--	14	--	04	--	10	02	--	--	02	--	--
Talbot	10	19	--	03	15	--	--	15	--	04	--	--	03	--	--	03	--	--
Pimlico	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--	--	--	--
Terrace Deposit		--	--	--	--	--	--	--	--	--	14	--	--	--	--	--	--	--
Swamp	--	--	03	--	--	04	--	---	--	--	--	--	--	--	--	--	--	--

Table 1 (con't) PIEDMONT AREA

FORMATION	Baltimore (04)	Carroll (07)	Cecil (08)	Frederick (11)	Harford (13)	Howard (14)	Montgomery (16)
Baltimore Gneiss	01	04	01	--	01	01	--
Sugarloaf Mt. - Quartzite	--	--	--	13	--	--	--
Setters	02	05	--	--	--	02	--
Wakefield Mt.	--	06	--	05	--	--	--
Cockeysville Marble	03	06	--	--	03	03	--
Harpers	--	12	--	11	--	--	--
Marburg Schist	--	11	--	02	--	--	--
Wissahickon East	04	09	02	--	04	04	01
Wissahickon West	05	08	--	--	04	05	02
Peters Creek	06	10	--	--	02	06	--
Antietam	--	12	--	12	--	--	--
Frederick	--	--	--	14	--	--	--
Grove	--	--	--	15	--	--	--
Cardiff	--	--	--	--	05	--	--
Peach Bottom	--	--	--	--	06	--	--
Baltimore Gabbro	07	--	04	--	08	08	--
Relay Quartz Diorite	11	--	--	--	--	11	--
Port Deposit Granite	12	--	03	--	09	--	--
Sykesville Granite	--	01	--	--	--	10	04
Ellicott City Granite	--	--	--	--	--	--	--
Woodstock Granite	13	--	--	--	--	--	--
Newark Group	--	--	--	--	--	--	09
New Oxford	--	--	--	17	--	--	--
Gettysburg Shale	--	15	--	18	--	--	--
Diabase	--	03	07	19	10	13	08
Serpentine	08	02	05	--	07	--	07

Table 1 (con't) RIDGE AND VALLEY AREA

FORMATION	Allegany (01)	Frederick (11)	Garrett (12)	Washington (22
Catoctin Metabasalt	--	08	--	01
Swift Run Tuff	--	06	--	--
Catoctin Metavolcanic	--	06	--	--
Loudoun	--	09	--	02
Weverton	--	10	--	03
Harpers	--	11	--	04
Antietam	--	12	--	05
Tomstown	--	--	--	06
Waynesboro	--	--	--	07
Conococheague	--	--	--	08
Beckmantown	--	--	--	09
St. Paul	--	--	--	10
Chambersburg	--	--	--	11
Martinsburg	--	--	--	12
Juniata	01	--	--	13
Tuscarora	02	--	--	13
Rosehill	03	--	--	14
Keefer	03	--	--	14
McKenzie	04	--	--	15
Wills Creek	04	--	--	15
Tonoloway	05	--	--	16
Keyser	05	--	--	16
Helderberg	05	--	--	16
Oriskany	06	--	--	17
Romney	07	--	--	18
Jennings	08	--	01	19
Hampshire	09	--	02	20
Pocono	10	--	03	21
Greenbrier	11	--	04	--
Mauch Chunk	12	--	05	--
Pottsville	13	--	06	--
Alleghany	13	--	06	--
Conemaugh	14	--	07	--
Monongahela	15	--	08	--
Dunkard	15	--	--	--

Table 2: Characteristics and Description of Each Geologic Formation by County

ALLEGANY COUNTY

1Shs Juniata Formation
(0101)

Soft shale, sandy shale, and thin-bedded sandstone, exposed only in the narrows of Wills Mountain, Cumberland.

2Ss Tuscarora sandstone
(0102)

Hard white and light gray sandstone (in part quartzite), mostly thick-bedded with minor thin beds of shale.

3Sh Rose Hill formation - Clinton Shale
(0103)

Chiefly shale; minor beds of sandstone and thin-bedded limestone; includes beds of iron ore (hematite).

4Ssh Wills Creek Shale and McKenzie formation
(0104)

Predominantly inter-bedded gray, greenish-gray, and red shale, shaly sandstone, and calcareous shale, with thin beds of argillaceous limestone and soft sandstone.

5Sl Tonoloway limestone, and Helderberg limestone
(0105)

Predominantly limestone beds, partly thick-bedded and cherty, partly thin-bedded and shaly, with subordinate shale beds, lower beds are thinly laminated.

6Ss Orinskany formation
(0106)

Lower part predominantly chert layers with shale partings; upper part loosely cemented calcareous sandstone.

7Sh Rommey shale
(0107)

Predominantly argillaceous shale, in part black (carbonaceous) with almost paper-thin bedding cleavage; subordinate thin beds of sandy shale and sandstone, and several thin beds of limestone.

8Ssh Jennings formation
(0108)

Predominantly sandy shale, dark gray or black in lower part of formation, and shaly sandstone with some hard quartzite and conglomerate beds in upper part. A very thick formation (4000 to 4800 feet).

9Ssh Hampshire formation
(0109)

Mixed beds of sandstone and shale, but predominantly sandstone, variably thin-bedded (flagstone) and thick-bedded (massive). Shale beds commonly red and brown.

10Ssh Pocono formation
(0110)

Mixed sandstone and shale; predominantly flaggy (thin platy) to massive sandstone, partly cross-bedded. Locally thin streaks of coaly material.

11Sl Greenbrier limestone
(0111)

Sandy limestone, in part cross-bedded, and interlayered with thinner beds of red shale.

12Sh Mauch Chunk shale
(0112)

Predominantly reddish shale.

13Ssh Pottsville and Allegany formations
(0113)

Mixed sandstone and shale, predominantly sandstone, some flaggy, some thick-bedded (massive). Includes some coal beds and underclays.

14Shsl Conemaugh formation
(0114)

Interbedded shale, black shale, fire-clay, coal, argillaceous limestone, and sandstone, all numerously repeated, and mostly as thin layers; several thick sandstone beds (up to 40 feet thick). "Iron nodules" and thin beds of iron ore are common.

15Shls Monongahela formation and Permian undifferentiated
(0115)

Repeated interbeds of shale, coal, fireclay (thin), limestone, and sandstone, predominantly (65% to 70%) shale, most of the sandstone and limestone beds are less than 6 feet thick.

1USgs (0201) Patuxent formation

Consists of beds of unconsolidated or slightly cemented sand, gravel, and large cobbles, and locally, thin lenses of clay cemented with iron oxides. Deposits may be 80 to 100 feet thick on divides. Locally, clay layers are prominent.

2USc (0202) Arundel formation

Chiefly clay with very minor amounts of sand. The formation characteristically contains organic (vegetable) matter of lignitic character. Locally contains iron concentrations as nodules and irregular, discontinuous lenses, which were formerly worked as iron ores; they have no present value.

3UScq (0203) Patapsco formation

Mostly clay and sandy clay, usually less than 80 feet thick; sand beds commonly 10 to 12 feet thick, but locally up to 30 feet.

4USsgc (0204) Raritan and Magothy formations

Mostly medium and fine sand, subordinately sand clay and clay; beds of sand commonly contain lenses and thin beds of gravel; locally lignite and pyrite are present; iron crusts (limonite) in many places.

5USsc (0205) Monmouth and Matawan formations

Sandy clay (lower part) and clayey to course sand (upper part); glauconitic throughout, with more "greensand" in upper half. Concentrations of limonite, limonite crusts, lignite, and pyrite common.

6USsc (0206) Aquia and Nanjemoy formations

Predominantly marly and glauconitic sand; upper part more clayey with clay beds locally dominent ("marlboro clay").

7USsc (0207) Calvert formation

Fine sand, clayey sand, and diatomaceous sandy clay ("fullers earth").

8USgs (0208) Brandywine formation

Gravel with considerable quartz sand matrix. Pebbles of quartzite, sandstone and chert; large cobbles in places. Thickness is up to 50 feet in places.

9USgs (0209)	Sunderland and Wicomico formations Gravel, sand, silt and clay beds, gravel predominant, boulders scant. Locally, south of Baltimore, gravels have been used by sand and gravel industries.
10USgs (0210)	Talbot formation Formation occupies the lowlands and is commonly less than 40 feet thick; consists of gravel, sand, clay and scattered boulders. Water table is apt to be high.

BALTIMORE COUNTY

LMMg Baltimore gneiss
(0401)

This formation is similar in mineral composition and grain texture to biotite granite and is classified by ASTM as a commercial granite. It is roughly layered (gneissic structure) and hence tends to break into thick slabs. In chemical and mineralogic composition it is comparable to granites, but with a somewhat higher content of mica flakes, which are segregated largely along the thinner layers.

In places the formation includes small areas and inclusions of the Setters formation, which is largely quartzite with subordinate schists; borders of the gneiss are comparatively thinly layered, representing a mixture of gneiss with quartzite and schist "ribbon gneiss."

2MMq Setters formation
(0402)

This formation consists of interlayered quartzite, mica schists, and thinly foliated granite gneiss; the layers commonly are thin and variable within short distances; thus, the formation lacks uniformity in composition.

3MMm Cockeysville marble
(0403)

Marble of variable texture, fine to coarse grained, with very low porosity. Color varies from white to light gray. Contains high magnesium (dolomitic) marble; subordinate high calcium in places.

4MMs Wissahickon schist, Southeastern facies
(0404)

A quartzose and feldspathic mica schist; includes some layers of gneiss and thin beds of quartzite; for the most part the rock is thinly foliated and splits easily along the planes of foliation, so that the soil cover is commonly thick and includes small platy fragments of the partly decomposed rock.

5MMp/MMs Wissahickon formation, Northwestern facies
(0405)

Thinly foliated, gray and greenish-gray, highly micaceous schist and phyllite, with a minor amount of interlayered thin beds of hard quartzite. The rock is generally soft except for the quartzite layers, and splits easily along the planes of foliation; flat slopes should generally be used in cuts where the foliation planes dip appreciably toward the cut. The topography is moderately rolling upland with generally narrow and shallow steep-walled valleys.

6MMs (0406) Peter's Creek Schist

Primarily beds of quartzite but includes prominent amount of quartz-mica schist; the proportions vary inwidely separated areas. Some of the layers are greenish. The derived soil is usually a sandy clay containing mica flakes, and commonly both rock and soil are weathered brown and reddish brown.

7la (0407) Gabbro

Dark gray to black rocks, in part greenish, of compact medium to coarse-grained texture. Includes several small areas of serpentine and pyroxenite.

8MMse (0408) Serpentine

Compact, dense, green rocks consisting chiefly of the mineral serpentine; commonly crossed by network of very thin veinlets, and slip surfaces of talc-like and asbestiform minerals.

9ly (0409) Pyroxenite

A dark green to nearly black crystalline, coarse-grained rock composed mostly of a pyroxene mineral.

10lg (0410) Gunpowder granite

A medium-grained granite, composed predominantly of feldspar and quartz, with (muscovite and biotite) as subordinate accessory minerals. Because the granite was intruded into the Wissahickon schist and its associated beds, the granite is alternately layered in places with these rocks along the borders of the areas.

11lqd (0411) Relay quartz diorite

A medium-grained crystalline, granitic rock composed of gray feldspar and a black mineral; contains a small amount of quartz (probably less than 5%).

12lg (0412) Port Deposit Gneiss Granite

A micaceous granitic rock with gneissic (thickly foliated) structure; variable amount of mica.

13lg (0413) Woodstock granite

Medium to coarse-grained biotite granite, light gray color.

14USgs (0414) Patuxent formation

Consists of beds of unconsolidated or slightly cemented sand, gravel and large cobbles, and locally, thin lenses of clay cemented with iron oxides. Thickness may be in excess of 150 feet.

15USc Patapsco formation
(0415)

Chiefly clay, but contains thin beds and lenses of sand and gravel. The clay beds are plastic, so that ingress of water along the sand and gravel lenses will promote slippage and instability along the interfaces on moderately steep slopes.

16USc Arundel formation
(0416)

Chiefly clay with very minor amounts of sand. Characteristically contains organic (vegetable) matter of lignitic character. Locally contains iron concentrations as nodules and irregular, discontinuous lenses, which were formerly worked as iron ores; they have no present value.

17USgc Raritan formation
(0417)

Variable formation including clay (variegated colors) sand, and gravel. Clay portions are carbonaceous (organic) in some places. Some sand layers are indurated (cemented) by iron oxides and silica in places, giving thin , hard ledges of red and brown colors.

18USgs Brandywine and Sunderland formations
(0418)

Gravel, sand, silt, and clay; pebbles and cobbles are largely of quartz and quartzite.

19USgs Talbot formation
(0419)

Largely gravelly sand, but with some thin beds of gravel, silt, and clay. Contains considerable organic matter in many places.

CALVERT COUNTY

1UScs (0501)	Nanjemoy and Chesapeake Groups Predominantly unconsolidated and sandy clay; subordinate beds of sand, marl, diatomaceous earth, and greensand (glauconite). Calcareous shells abundant. Locally, thin beds of sand have been cemented into sandstone.
2USsg (0502)	Columbia group Beds of sand gravel, sand, silt, and clay of variable thickness, but predominantly sand and gravel.
3 (0503)	Swamp or Marshland

CAROLINE COUNTY

1UScs Calvert and Choptank formations
(0601)

Clay and sandy clay, with thin beds of marl and diatomaceous earth, but all materials are variable and grade into each other. The formation is predominantly sandy.

2USsgc Wicomico formation
(0602)

Clay, sand, and gravel, all in relatively thin beds that grade into each other both horizontally and vertically. Locally the sand is cemented by iron oxides into a sandstone, forming a hardpan. Scattered boulders present.

3UScsg Talbot formation
(0603)

Variable clay, sand, gravel, scattered boulders, and some thin beds of peat; all grade into each other laterally and vertically. Sandy clay predominates in this formation.

CARROLL COUNTY

1MMg Sykesville Granite
(0701)

Dark greenish-gray biotite granite-gneiss, variable texture; considerable alteration to green secondary minerals (chlorite, epidote). Many veins in places, and inclusions of schist.

2MMse Serpentine
(0702)

Compace, dense, green rocks consisting chiefly of the mineral serpentine; commonly crossed by network of very thin veinlets, and slip surfaces of talc-like and asbestiform minerals.

3Id Diabase
(0703)

Vertical tabular body of dense, black volcanic rock ("trap" rock).

4MMg Baltimore gneiss
(0704)

This formation is similar in mineral composition and grain texture to biotite granite, and is classified by ASTM as a commercial granite. It is roughly layered (gneissic structure) and hence tends to break into thick slabs. In chemical and mineralogic composition it is comparable to granites, but with somewhat higher content of mica flakes, which are segregated largely along the thinner layers.

5MMq Setters formation
(0705)

This formation consists of interlayered quartzite, mica schists, and thinly foliated granite gneiss; the layers commonly are thin and variable within short distances; thus the formation lacks uniformity in composition.

6MMm Cockeysville and Wakefield marble
(0706)

White and gray marble, mostly fine-grained, partly coarse-grained in places contains infolded thin layers of mica and chlorite schists, phyllite and slate.

7Iv Basic and Acid Volcanic rocks
(0707)

Chiefly dark green to black dense volcanic rocks, interbedded schists, chiefly mica and chlorite schists, dark-green to nearly black schists of variable composition, and phyllite; includes some thin beds of Wakefield marble. The schists include the meta-volancis rocks-metarhyolite, meta-andesite, Sams creek meta-basalt, and Ijamsville phyllite of other area reports.

8MMp/MMs Wissahickon formation, Northwestern Facies
(0708)

Thinly foliated, gray and greenish-gray, highly micaceous schist and phyllite, with a minor amount of interlayered thin beds of hard

quartzite. The rock is generally soft except for the quartzite layers and splits easily along the planes of foliation; flat slopes should generally be used in cuts where the foliation planes dip appreciably toward the cut. The topography is moderately rolling upland with generally narrow and shallow steep-walled valleys.

9MMs (0709) Wissahickon formation, Southeastern facies

A quartzose and feldspathic mica schist; includes some layers of gneiss and thin beds of quartzite; forthe most part the rock is thinly foliated and splits easily along the planes of foliation, which are apt to be of open texture, permitting a marked absorption of water. In many places the weathering is deep along joints and planes of foliation, so that the soil cover is commonly thick and includes small platy fragments of the partly decomposed rock.

10MMs (0710) Peter's Creek formation

Primarily beds of quartzite but includes prominent amount of quartz-mica schists; the proportions vary in widely separated areas. Some of the layers are greenish. The derived soil is usually a sandy clay containing mica flakes, and commonly both rock and soil are weathered brown and reddish brown.

11MMq (0711) Loudoun formation and Marburg schist

Consists of quartzite and conglomerate.

12MMs (0712) Consists partly of the Loudon, Harpers, Chickies, and Antietam formations

Chiefly mica and chlorite schists and slate, locally includes thick lenses of quartzite and conglomerate.

13Sl (0713) Conestoga limestone or Silver Run limestone

Thin bedded and slaty, bluish-gray limestone.

14Ss (0714) New Oxford arkosic sandstone

Interlayered sandstone, arkosic sandstone, and shale, predominantly red and purplish-red; subordinately light gray and yellow beds of arkosic sandstone; all contain flakes of mica. The formation is of variable hardness owing to variable cementation and porosity. The Sandstone beds are of variable but relatively high porosity as compared with the shale beds and older rocks of the region, which have relatively low porosity.

15Ssh (0715) Gettysburg shale

Very thick formation composed mostly of red shale with interlayered subordinate thin beds of soft red sandstone.

CECIL COUNTY

1MMg Baltimore gneiss
(0801)

This formation is similar in mineral composition and grain texture to biotite granite, and is classified by ASTM as a commercial granite. It is roughly layered (gneissic structure) and hence tends to break into thick slabs. In chemical and mineralogic composition it is comparable to granites, but with somewhat higher content of mica flakes, which are segregated largely along thinner layers.

2MMs Wissachickon formation, Southeastern facies
(0802)

A quartzose and feldspathic mica schist; includes some layers of gneiss and thin beds of quartzite; for the most part the rock is thinly foliated and splits easily along the planes of foliation, which are apt to be of open texture, permitting a marked absorption of water. In many places the weathering is deep along joints and planes of foliation, so that the soil cover is commonly thick and includes small platy fragments of the partly decomposed rock.

3Ig Port Deposit granite
(0803)

A micaceous granitic rock with gneissic (thickly foliated) structure; variable amount of mica.

4Ia Gabbro
(0804)

Dark gray to black rocks, in part greenish, of compact medium to coarse-grained texture. Includes several small areas of serpentine and pyroxenite.

5MMse Serpentine
(0805)

Compact, dense, green rocks consisting chiefly of the mineral serpentine; commonly crossed by network of very thin veinlets, and slip surfaces of talc-like and asbestiform minerals.

6MMmr Meta-rhyolite
(0806)

Dense-textured gray and greenish-gray volcanic rocks.

7Id Diabase
(0807)

Vertical tabular body of dense, black volcanic rock ("trap"rock).

8USgs Patuxent Formation
(0808)

Consists of beds of unconsolidated or slightly cemented sand, gravel, and large cobbles, and locally, thin lenses of clay cemented with iron oxides.

9USc (0809)	Patapsco formation Clay, sandy clay, and fine sand, small amounts of gravel as lenses and thin beds.
10UScsg (0810)	Patuxent and Patapsco formation Sand and clay in variable proportions, with local thin lenses and beds of gravel.
11Ussc (0811)	Raritan formation Fine and medium grained sand; subordinate sandy clay and clay.
12Uss (0812)	Monmouth formation Medium and fine-grained sand, brown or reddish-brown at top; thin greensand at base considerably oxidized in places to limonite crusts.
13Uss (0813)	Aquia formation Sand, largely greensand partly indurated, and subordinate marl.
14Usgs (0814)	Lafayette formation (Brandywine) Coarse sand and gravel; locally indurated to sandstone and conglomerate, with crusts of limonite.
15Usgs (0815)	Sunderland, Wicomico and Talbot formations Gravel, sand, and subordinate clay beds of the coastal plain area.

CHARLES COUNTY

1UScs (0901) Nanjemoy and Calvert formations

Predominantly fine sand and clayey sand, including thin beds of distomaceous earth and medium textured sand, in places cemented to sandstone; lower part of formation (in valleys of northern part of the county) is more clayey and greenish in color owing to presence of greensands (glauconite).

2USgs (0902) Brandywine formation

Interbedded sand and gravel, with very subordinate thin lenses of clay and silt. Fine to coarse sand predominates in lower part of formation; variable sorted gravel in upper part, commonly orange to red colors.

3UScsg (0903) Columbia group

Interbedded thin beds of clay, silt, sand, and gravel, locally with boulders.

4 (0904) Swamp or Marsh

DORCHESTER COUNTY

*1001 Undifferentiated sands, clays and gravels.

Gray to buff sand and gravel, gray to brown lignitic silt and clay, occasional boulders, includes surficial deposits that occur as intercalated fluvial sands and marsh muds; well sorted, stabilized dune sands, shell bearing estuarine clays and silts, and beach zone sands, also subsurface deposits of pre-Wisconsin age buff to reddish brown sand and gravel.

1002 Manokin Aquifer

Shows area influenced by aquifer recharge in the materials of 1001.

*No letter-number symbol available because map not produced with series in 1965.

FREDERICK COUNTY

1MMp/MMmr Ijamsville phyllite and Metarhyolite
(1101)

Thinly foliated schistose rocks consisting of complexly interlayered phyllite, slate, and fine-grained schist, variously colored (blue, green purple, and gray layers) containing many short and thin, distorted lenticles of quartz. Some layers are appreciably porous. Included with this assemblage are countless lenses and beds of quartzite up to 30 feet thick, but commonly much thinner; some of the quartzite layers are prominently weathered to a porous quartz rock, markedly stained with brown iron oxide (Limonite), but some of the quartzite beds are white, dense, and unweathered. Because of their general similarities in structure and behavior, as well as the difficulty in separating different facies, the ijamsville phyllite, metarhyolite and meta-andesite are therefore shown together on the county geological map.

2MMs Marburg schist
(1102)

Thinly foliated, fine-grained micaceous, chloritic, and quartzose schists, bluish-gray to silvery green; contains many thin beds and lenses of quartzite up to 15 feet thick, but many less than five feet thick.

3MMmb Metabasalt
(1103)

Greenish-gray to green, schistose and massive fine-grained (also known as "greenstone"); slaty layers in places.

4MMp Urbana phyllite
(1104)

Much of this formation is a massive, white, coarsely granular quartz rock that makes prominent ridges. Most of this formation is thinly foliated greenish-gray quartz-mica schist and quartzite, weathering fairly readily to a somewhat porous limonite-stained mass. Contains beds of quartzite, some of which are more than 40 feet thick.

5MMm Wakefield marble
(1105)

White fine-grained marble, locally with thin interbeds of quartzite and schist, both of which are very subordinate in amount. Small areas, not large enough to be mapped, have been included in the Ijamsville phyllite or the Metabasalts.

611 Aporhyolite, Rhyollite, Tuff and Breccia
(1106)

High-silica volcanic rocks, chiefly of very dense texture (originally glassy texture), containing subordinate beds of fragmental siliceous volcanic rocks, (tuff and breccia); gray to blue, pink and red. Microscopically the rock is seen to be composed chiefly of feldspar and quartz grains.

7Ii Schists with intruded igneous rocks of various kinds
(1107)

An area of mixed igneous rocks of several varieties (granite, metabasalt, et. al) that are complexly interwoven and not separable for mapping purposes represents complex intrusions, especially dikes, wells, and stocks, into pre-existing schists. Parts of the complex are gneissic, parts schistose, and parts are dense, massive diabase ("trap") as dikes of various widths.

8MMmb Catoctin metabasalt
(1108)

Dense, hard, green to dark greenish-gray volcanic rocks; commonly shows thin laminations originally as volcanic flow structure. In part the rock is vesicular. Includes minor, narrow lenses of slaty and schistose beds and small intrusions of granite.

9MMp Loudoun formation
(1109)

Largely dark slate thin-bedded arkosic (feldspathic) quartzite with many interbeds of purer quartzite, schist, thin beds of limestone, and phyllite; some of the quartzite beds, especially those near the base of the formation, are conglomerate with pebbles up to 4 inches in diameter.

10MMq Weverton quartzite
(1110)

Generally thick bedded, blocky quartzite; locally contains subordinate thin slabby beds. White, gray and bluish-gray layers; lower beds of the formation are less uniform with arkosic (feldspathic) and conglomerate layers prominent.

11MMp Harpers Phyllite
(1111)

Gray, thinly foliated phyllite and slate beds; contains subordinate green schist and thin quartzite beds, also thin veins and lenses of quartz.

12MMq Antietam quartzite
(1112)

Thinly bedded quartzite; in part a schist, and in part containing some calcite. Weathers to a rusty, rather porous, granular material. The lower part especially is thinly foliated (quartzite sericite schist). Thickness usually 20 to 30 feet.

13MMq Sugarloaf quartzite
(1113)

Predominantly thick beds of quartzite, with an included thick layer of schistose and slaty quartzite.

14Sl Frederick Limestone
(1114)

Thin-bedded dark blue-gray slabby argillaceous limestone with numberous thin shaly partings. Blue-gray where not weathered. Locally includes a thick (20 feet) bed of thinly laminated limestone.

15Sl Grove Limestone
(1115)

Thick-bedded blusih-gray to light gray, high-calcium limestone; contains subordinate beds of magnesium limestone, and quartzose (sandy) limestone at base. White, gray and blue-gray beds. Weathers to buff color. Formation usually 150 to 200 feet thick.

16Sl Limestone conglomerate
(1116)

Predominantly limestone matrix with pebbles of limestone and quartz.

17Ss New Oxford formation
(1117)

Interlayered sandstone, arkosic sandstone, and shale, predominantly red and purplish-red; subordinately light gray and yellow beds of arkosic sandstone; all contain flakes of mica. The formation is of variable hardness owing to variable cementation and porosity. The sandstone beds are of variable but relatively high porosity as compared with the shale beds and older rocks of the region, which have relatively low porosity. The lower part of the formation (eastern border of area north of route US 40) is composed mostly of thick beds of conglomerate interbedded with red arkosic sandstone.

18Ssh Gettysburg shale
(1118)

Very thick formation composed mostly of red shale with interlayered subordinate thin beds of soft red sandstone.

19Id Diabase
(1119)

A fine-grained to dense textured crystalline igneous rock. The rock was intruded into the Triassic sedimentary beds (Ss/Sh) as narrow vertical dikes and as horizontal tabular sills at the Pennsylvania border. Weathering in the nearly flat upland areas of the sill may be as much as 20 feet deep and the residual clay contains rounded blocks of soft, partly weathered rock.

20AF Alluvial cones
(1120)

Extensive alluvial cones and fans along eastern base of Catoctin mountain ridge; composed of gravels and sands of greatly variable texture, including many boulders and cobbles, generally coarser-textured toward the mountain slopes. Pebbles chiefly of quartzite, but many slaty fragments are included. Sand content increases toward the east.

21AT Alluvial Terrace
(1121)

Gravel and sand of alluvial origin at altitudes of about 300 and 400 feet. Cobbles and large pebbles are abundant; thickness of deposits variable; generally not greater than 25 feet.

22AR Alluvium
(1122)

Flood plain fine sand, silt, and clay with included thin layers and lenses of fine gravels along Potomac River.

GARRETT COUNTY

1Shs (1201) Jennings formation

Interbedded sandstone, siltstone, shale, predominantly shale.

2Ssh (1202) Hampshire formation

Mixed shale and sandstone, predominantly sandstone.

3Ssh (1203) Pocono formation

Mixed sandstone and shale; predominantly flaggy (thin platy) to massive sandstone, part cross-bedded. Locally thin streaks of coaly material.

4Ssh (1204) Greenbrier formation

Limey sandstone and shale, subordinate sandy limestone; contains sandy limestone bed 40 to 50 feet thick in upper part.

5Ssh (1205) Mauch Chunk formation

Thin-bedded, micaceous sandstone, and interbedded sandy shale and shale.

6Ssh (1206) Allegheny and Pottsville formations

Mixed sandstone and shale, predominantly sandstone, some flaggy, some thick-bedded (massive). Includes some coal beds and underclays.

7Shsl (1207) Conemaugh formation

Interbedded shale, black shale, fire-clay, coal, argillaceous limestone and sandstone, all numerously repeated, and mostly as thin layers; several thick sandstone beds (up to 40 feet thick). "Iron nodules" and thin beds of iron ore are common.

8Shls (1208) Monongahela formation

Many repeated interbeds of shale, coal, fireclay, (thin) limestone, and sandstone; predominantly (65% to 70%) shale, most of the sandstone and limestone are less than 6 feet thick.

HARFORD COUNTY

1MMg
(1301) Baltimore gneiss

This formation is similar in mineral composition and grain texture to biotite granite and is classified by ASTM as a commercial granite. It is roughly layered (gneissic structure) and hence tends to break into thick slabs. In chemical and mineralogic composition it is comparable to granites, but with somewhat higher content of mica flakes, which are segregated largely along thinner layers.

2MMs
(1302) Quartz schist (Peters Creek schist)

Primarily beds of quartzite but includes prominent amount of quartz-mica schist; the proportions vary in widely separated areas. Some of the layers are greenish. The derived soil is usually a sandy clay containing mica flakes, and commonly both rock and soil are weathered brown and reddish-brown.

3MMm
(1303) Cockeysville marble

Marble of variable texture, fine to coarse grained, very low porosity. Color varies from white to light gray. Composition: contains high magnesium (dolomitic) marble; subordinate high calcium in places.

4MMs
(1304) Wissahickon formation (both facies)

Predominantly mica-schist, subordinate layers of slate, quartzite, and gneiss.

5MMc
(1305) Cardiff conglomerate

Quartzite and quartzite conglomerate.

6MMl
(1306) Peach Bottom slate

Dark-gray, nearly black, slate.

7MMse
(1307) Serpentine

Compact, dense, green rocks consisting chiefly of the mineral serpentine; commonly crossed by network of very thin veinlets, and slip surfaces of talc-like and asbestiform minerals.

8Ia
(1308) Gabbro and Metagabbro

Dark gray to black rocks, in part greenish, of compact medium to coarse grained texture. Includes several small areas of serpentine and puroxenite.

9Ig (1309)	Port Deposit Granite A micaceous granitic rock with gnessic (thick foliated) structure; variable amount of mica.
10Id (1310)	Diabase Vertical tabular body of dense, black volcanic rock ("trap" rock).
11USgs (1311)	Patuxent formation Consists of beds of unconsolidated or slightly cemented sand, gravel and large cobbles, and locally, thin lenses of clay cemented with iron oxides.
12USc (1312)	Patapsco formation Chiefly clay, but contains thin beds and lenses of sand and gravel. The clay beds are plastic, so that ingress of water along the sand and gravel lenses will promote slippage and instability along the interfaces on moderately steep slopes.
13USgs (1313)	Lafayette formation (Brandywine) Lower part, up to 50 feet, consists of sand and gravel; upper part, 10 to 20 feet, consists of sand and silt. Pebbles, chiefly quartz, chert, quartzite, and sandstone, are common.
14USgs (1314)	Wicomico and Sunderland formations Gravel and sand, subordinate silt and clay; small amount of organic material (peat).
15USsg (1315)	Talbot formation Largely gravelly sand, but with some thin beds of gravel, silt, and clay. Contains considerable organic matter in many places.

1MMg Baltimore Gneiss
(1401)

This formation is similar in mineral composition and grain texture to biotite granite, and is classified by ASTM as a commercial granite. It is roughly layered (gneissic structure) and hence tends to break into thick slabs. In chemical and mineralogic composition it is comparable to granites, but with somewhat higher content of mica flakes, which are segregated largely along thinner layers.

2MMq Setters formation
(1402)

This formation consists of interlayered quartzite, mica schists, and thinly foliated granite gneiss; the layers commonly are thin, and variable within short distances; thus, the formation lacks uniformity in composition.

3MMm Cockeysville marble
(1403)

Marble of variable texture, fine to coarse grained, very low porosity. Color varies from white to light gray. Contains high magnesium (dolomitic) marble; subordinate high calcium in places.

4MMs Wissahickon schist (Southeastern facies)
(1404)

A quartzose and feldspathic mica schist; includes some layers of gneiss and thin beds of quartzite; for the most part the rock is thinly foliated and splits easily along the planes of foliation, which are apt to be of open texture, permitting a marked absorption of water. In many places the weathering is deep along joints and planes of foliation, so that the soil cover is commonly thick and includes small platy fragments of the partly decomposed rock.

5MMp/MMs Wissahickon formation (Northwestern facies)
(1405)

Thinly foliated, gray and greenish-gray, highly micaceous schist and phyllite, with a minor amount of interlayered thin beds of hard quartzite. The rock is generally soft except for the quartzite layers and splits easily along the places of foliation; flat slopes should generally be used in cuts where the foliation planes dip appreciable toward the cut.

6MMs Peter's Creek formation
(1406)

Primarily beds of quartzite but includes prominent amount of quartz-mica schist; the proportions vary in widely separated areas. Some of the layers are greenish. The derived soil is usually a sandy clay containing mica flakes, and commonly both rock and soil are weathered brown and reddish brown.

7MMg Laurel granite
(1407)

A crystalline rock of generally granitic composition and pronounced

gneissic (coarsely foliated) structure, but variable in both composition and structure; in most places it is a gneissic granite, but in a few places it is thinly foliated and similar to schist of the Wissahickon formation. In many outcrops it closely resembles the more granitic parts of the Sykesville formation, but it differs in lacking beds of quartzite. The Laurel migmatite is generally hard, and is weakly cleavable along planes of foliation, breaking into thick slabs, except the subordinate schistose portions break readily into thin slabs. Most of the formation will sustain steep cut walls.

8la Gabbro
(1408)

Dark gray to black rocks, in part greenish, of compact medium to coarse grained texture. Includes several small areas of serpentine and pyroxenite.

9MMse Serpentine
(1409)

Compact, dense, green rocks consisting chiefly of the mineral serpentine; commonly crossed by a network of very thin veinlets. and slip surfaces of talc-like and asbestiform minerals.

10MMg Sykesville formation
(1410)

The formation consists of crystalline rocks of generally gneissic structure and granitic composition, but includes some stringers and lenses of massive granitic rock, and in places is complexly interlayered with beds of quartzite and granitic gneiss. Mapping of separate facies is impracticable, inasmuch as they grade into each other both along and across the layers, particularly at and near the borders of the area. The more schistosic layers break easily along planes of foliation and in crushing will yield thin, platy fragments. The predominant gneissic layers break to yield slab-like blocks; they have been quarried for dimension stone and crushed stone.

11lqd Relay quartz diorite
(1411)

A medium-grained crystalline, granitic rock composed of gray feld spar and a black mineral; contains a small amount of quartz (probably less than 5%).

12lg Ellicott City granite and Guilford granite
(1412)

Granite and granite-gneiss, medium to coarse-grained; gneissic structure in places.

13ld Diabase
(1413)

Vertical tabular body of dense, black volcanic rock ("trap" rock).

14USgs Patuxent formation
(1414)

Consists of beds of unconsolidated or slightly cemented sand, gravel, and large cobbles, and locally, thin lenses of clay cemented with iron oxides.

KENT COUNTY

1USsgc (1501)	Raritan, Magothy, and Matawan formations Sand, subordinate beds of gravel and clay. Some beds of sand and gravel are firmly indurated by iron oxides and constitute a firm "hardpan." Clay with lignitic material and much pyrite and marcosite are prominent locally in middle beds, which outcrop in upper parts of valley walls and can be reached by shallow excavation in bordering upland areas. Uppermost beds of sand and clay contain prominent amounts of greensand. Exposed thickness in valleys is up to 40 feet.
2USsc (1502)	Monmouth and Aquia formations Sands containing much glauconite ("greensand"), and iron oxides as crusts and concretions.
3USs (1503)	Calvert formation Fine to medium textured sand; white, buff, gray; locally indurated with limonite.
4USsg (1504)	Wicomico and Talbot formations Predominantly sand beds of variable textures, fine to coarse, with some relatively thin interbeds of fine to medium textured gravel; locally thin interbeds of clay, very subordinate in amount. Scattered boulders.

MONTGOMERY COUNTY

1MMs Wissahickon formation, eastern facies
(1601)

A quartzose and feldspathic mica schist; includes some layers of gneiss and thin beds of quartzite; for the most part the rock is thinly foliated and splits easily along the planes of foliation, which are apt to be of open texture, permitting a marked absorption of water. In many places the weathering is deep along joints and planes of foliation, so that the soil cover is commonly thick and includes small platy fragments of the partly decomposed rock.

2MMp/MMs Wissahickon formation, western facies
(1602)

Thinly foliated, gray and greenish-gray, highly micaceous schist and phyllite, with a minor amount of interlayered thin beds of hard quartzite. The rock is generally soft except for the quartzite layers, and splits easily along the planes of.foliation; flat slopes should generally be used in cuts where the foliation planes dip appreciably toward the cut. The topography is moderately rolling upland with generally narrow and shallow steep walled valleys. Rock outcrops are numerous along the valley walls but rare in upland areas, where the formation is commonly covered by a micaceous clayey soil.

3It/Igh Tonalite and Bear Island grandiorite
(1603)

Coarse to medium-grained igneous rocks of variable composition, consisting of light colored feldspar, dark-green to black hornblende, mica, and a small amount of quartz. The rocks are in part non-foliated and in part weakly foliated. The rock will cleave roughly along foliation planes, but in general will break into blocks rather than in thin slabs, and will maintain steep slopes except where closely jointed. The thin soil cover is clayey and is moderately iron-stained (limonite). Gently rolling upland areas with numerous rock exposures.

4MMg Sykesville formation
(1604)

The formation consists of crystalline rocks of generally gneissic structure and granitic composition, but includes some stringers and lenses of massive granitic rock, and in places is complexly interlayered with beds of quartzite and granitic gneiss. Mapping of separate facies is impracticable, inasmuch as they grade into each other both along and across the layers, particularly at and near the borders of the area. The more schistose layers break easily along planes of foliation, and in crushing will yield thin, platy fragments. the predominant gneissic layers break to yield slab-like blocks; they have been quarried for dimension stone and crushed stone.

5MMg Laurel migmatite
(1605)

A crystalline rock of generally granitic composition and pronounced gneissic (coarsely foliated) structure, but variable in both composition and structure; in most places it is a gneissic granite,

but in a few places it is thinly foliated and similar to schist of the Wissahickon formation. In many outcrops it closely resembles the more granitic parts of the Sykesville formation, but it differs in lacking beds of quartzite. The Laurel migmatite is generally hard, and is weakly cleavable along planes of foliation, breaking into thick slabs, except that the subordinate schistose portions break readily into thin slabs. Most of the formation will sustain steep cut walls.

6MMg (1606) Kensington Gneiss

A massive, medium-grained granite gneiss rather uniform in composition and texture. The rock has vertical and inclined joints (cracks) which form relatively thick blocks. Thickness of joint blocks increases with depth.

7MMse (1607) Serpentine

An altered igneous intrusive rock. Although a fairly soft rock, the denser portions are commonly harder and tough to drill. The rock is commonly streaked with veinlets of secondary minerals, such as dolomite, and the rock is susceptible to breaking along these veins. The rock weathers slowly to give iron oxides (limonite) mixed with some clay, hence weathered exposures are commonly stained brown.

8Id (1608) Diabase

A fine-grained to dense-textured crystalline igneous rock. The rock was intruded into the Triassic sedimentary beds (Ss/Sh) as narrow vertical dikes, and as a horizontal tabular sill, about 80 feet thick in the vicinity of Bucklodge. Weathering in the nearly flat upland areas of the sill may be up to 20 feet deep and the residual clay contains rounded blocks of soft, weathered rock. Exposed abundantly around the periphery of the area and along the walls of Little Seneca Creek. The dikes weather similarly.

9Ss/Sh (1609) Newark group, largely New Oxford formation

Predominantly beds of red, purple, and brown sandstone; subordinate beds of shale. In general, the formation is relatively soft, owing to weak cementation of the sand grains, but locally is moderately hard. Red oxides of iron are responsible for the color and in part serve to cement the sand grains. The subordinate shale beds break easily along the bedding planes, yielding small thin flakes. The beds dip westerly at low angles -- 5 to 25 degrees. Under weathering the sandstone beds yield red clayey sand and the shale beds yield more compact red clay soils.

10Ib (1610) Basic igneous rocks

Dark greenish-gray to black, coarse to fine-grained granitoid rocks of variable composition, but composed dominantly of black minerals, chiefly hornblendes and augite. This category includes several varieties of closely similar rocks that cannot be separated

satisfactorily in mapping, owing to irregularities and interpenetrations of small units; they are therefore combined into a general category. the following properties characterize most of the units of this group: foliation is weak and the rocks tend to break into moderately sized polygonal blocks rather than thin flat slabs; rather close jointing gives many of the outcrops a blocky structure; the jointing has tended to promote somewhat rounded, weathered boulders in the thin soil overburden. These basic rocks are commonly tough to drill due to comparatively high elasticity.

11MMp (1611) Ijamsville phyllite

Thinly foliated phyllite composed chiefly of microscopic flakes of mica, but with numerous small veinlets and lenses of quartz. Intersection of thin cross-cleavages and foliation planes gives crinkled cleavage surfaces, and commonly two cleavage planes at large angles to each other are present so that the rock breaks readily into elongated blocks -- "fence post schists."

12USgs (1612) Patuxent formation

Consists of beds of unconsolidated or slightly cement sand, gravel, and large cobbles, and locally, thin lenses of clay cemented with iron oxides. Deposits may be up to 70 feet thick on divides; thinner on valley walls, except near the base where creep has thickened the detritus. Locally, clay layers are prominent.

13USc (1613) Patapsco Formation

Chiefly clay, but contains thin beds and lenses of sand and gravel. The clay beds are plastic, so that ingress of water along the sand and gravel lenses will promote slippage and instability along the interfaces on moderately steep slopes. The lower part of the formation as exposed in Montgomery County is generally more clayey than the upper part.

14AT (1614) Terrace gravels

An alluvial deposit consisting chiefly of coarse gravels with a prominent amount of sand matrix, thin beds of sand, and very subordinate thin lenses of silt and clay. Contains well rounded pebbles and cobbles of resistant materials, chiefly quartz and chert. The formation underlies flat areas on uplands as remnants of early river terraces, usually of small extent; some exceptions are the area south of Martinsburg and other fairly large areas north of Edwards Ferry. Elsewhere very small patches are found from 1000 to 3000 feet across.

15AR (1615) Flood plains

Alluvium along principal valleys, consisting of sand and silt with subordinate thin beds of clay and of medium to fine gravel. Large cobbles and boulders are sparse and local.

PRINCE GEORGE'S COUNTY

1USgs Patuxent formation
(1701)

Consists of beds of unconsolidated or slightly cemented sand, gravel, and large cobbles, and locally, thin lenses of clay cemented with iron oxides.

2USsc Patapsco formation
(1702)

Chiefly clay, but contains thin beds and lenses of sand and gravel. The clay beds are plastic, so that ingress of water along the sand and gravel lenses will promote slippage and instability along the interfaces on moderately steep slopes.

3Ig/MMg Laurel granite-gneiss
(1703)

A crystalline rock of generally granitic composition and pronounced gneissic (coarsely foliated) structure, but variable in both composition and structure; in most places it is a gneissic granite, but in a few places it is thinly foliated and similar to schist of the Wissahickon formation. In many outcrops it closely resembles the more granitic parts of the Sykesville formation, but it differs in lacking beds of quartzite. The Laurel migmatite is generally hard, and is weakly cleavable along planes of foliation, breaking into thick slabs, except the subordinate schistose portions break readily into thin slabs. Most of the formation will sustain steep cut walls.

4USs Monmouth formation
(1704)

Gray-green to mostly black fine sand containing abundant flakes of mica. At the base of the formation is a gravel bed, which is about two feet thick and contains well-rounded pebbles. The upper part of the formation is finer-textured, more micaceous, and weathers to a brown color. The thickness varies to 100 feet on divides but with the average is about 60 feet.

5USs Aquia greensand
(1705)

A fine to medium textured sand, maximum thickness of 100 to 120 feet. The formation is much like the upper part of the Monmouth formation, but is somewhat finer-textured and contains a prominant amount of glauconite ("greensand"), which in some thin beds is the predominant material. The formation contains no gravel but in the lower beds, just above the Monmouth formation, nodules of calcium phosphate are found. Some beds of the Aquia contain abundant shell fragments and may therefore be slightly cemented by calcium carbonate; in these beds clay minerals are also abundant (marl beds).

6USc Nanjemoy formation
(1706)

The lower bed consists of pink plastic clay, up to 30 feet thick, overlain by fine-textured mica-bearing sand; also contains variable amount of glauconite ("greensand"). Thickness reported up to 125 feet but generally 100 feet or less in Prince George's County.

7USsc Chesapeake group
(1707)

Chiefly gray clay with subordinate beds of fine sand and sandy clay; glauconite in base layer. Formation up to 140 feet thick in Prince George's County as exposed along Hanson Creek where it lies upon the Aquia greensand. In the eastern and southeastern part of the county it is thinner (80 feet) and it lies upon the Nanjemoy formation (clay and micaceous glauconiteic sand). These two formations are so similar in many places that a separation cannot readily be made.

8USgs Brandywine formation
(1708)

Gravel with considerable quartz sand matrix. Pebbles of quartzite, sandstone and chert; large cobbles in place, especially in northern part of the area (central part of county). The gravel is not well graded, but the average size of pebbles decreases toward the south and southeast. Much of the gravel contains in excess of 50% pebbles up to two inches in diameter. The thickness of the formation is up to 60 feet in northern part of the area, thinner (20 to 40 feet) toward the southern and eastern part.

(USgs Sunderland formation
(1709)

Coarse, poorly sorted gravel of greatly variable texture, boulders up to 18 inches; sand matrix; in places some thin beds and lenses of silt and clay, locally up to 6 feet thick. Formation is commonly colored orange-red and yellow by iron oxides. Thickness is up to 50 feet thick, but quite variable within short distances.

10USgc Wicomico formation
(1710)

The formation consists mainly of gravel, commonly capped by several feet of silt; locally thin beds of carbonaceous clay below the gravel. Gravel consists chiefly of quartz with minor amount of chert. Thickness is up to 50 feet but is generally less than 30 feet. Beds are not of uniform thickness because the formation was deposited on a dissected surface and was later cut into by present streams, so that in the narrower belts (along valleys) both the upper and the lower surfaces slope appreciably.

11AR Pimlico and Recent alluvium
(1711)

The formation consists of gravel, sand, and silt at low levels along the Potomac and Patuxent valleys and along the lower reaches of their principal tributaries. Formation also includes present alluvium and delta deposits. Proportions of gravel, sand, and silt are variable. the amount of finer material increases toward south and southeast along the Potomac and Patuxent Rivers and their major tributaries.

QUEEN ANNE'S COUNTY

1UScs (1801) Calvert and Aquia formations

Clay and sandy clay, with thin beds of marl and diatomaceous earth, but all materials are variable and grade into each other. The formation is predominantly sandy.

2USsgc (1802) Wicomico formation

Clay, sand, and gravel, all in relatively thin beds that grade into each other both horizontally and vertically. Locally the sand is cemented by iron oxides into a sandstone forming a hardpan. Scattered boulders present.

3UScsg (1803) Talbot formation

Variable clay, sand, gravel, scattered boulders, and some thin beds of peat; all grade into each other laterally and vertically. Sandy clay predominates in this formation.

ST. MARY'S COUNTY

1UScs Chesapeake group
(1901)

Predominantly unconsolidated clay, sandy clay; subordinate beds of sand, marl, diatomaceous earth, and greensand (glauconite). Calcareous shells abundant. Locally, thin beds of sand have been cemented into sandstone.

2USgs Lafayette formation (Brandywine)
(1902)

Clay, fine gravel mostly in lower part.

3UScsg Columbia group
(1903)

Clay, silt, sand, and gravel; predominantly sandy clay, but sand and gravel locally prominent.

SOMERSET COUNTY

*2001 Undifferentiated sands, clays and gravel.

Gray to buff sand and gravel, gray to brown lignitic silt and clay, occasional boulders, includes surficial deposits that occur as intercalated fluvial sands and marsh muds; well sorted, stabilized dune sands, shell bearing estuarine clays and silts, and beach zone sands, also subsurface deposits of pre-Wisconsin age, buff to reddish-brown sand and gravel.

2002 Pocomoke Aquifer

Shows area influenced by aquifer recharge in the materials of 2001.

*No letter-number symbol available because map not produced with series in 1965.

TALBOT COUNTY

1UScs (2101) Calvert and Choptank formations

Clay and sandy clay, with thin beds of marl and diatomaceous earth, but all materials are variable and grade into each other. The formation is predominantly sand.

2USsgc (2102) Wicomico formation

Clay, sand, and gravel, all in relatively thin beds that grade into each other both horizontally and vertically. Locally the sand is cemented by iron oxides into a sandstone forming a hardpan. Scattered boulders present.

3UScsg (2103) Talbot formation

Variable clay, sand, gravel, scattered boulders, and some thin beds of peat; all grade into each other laterally and vertically. Sandy clay predominates in this formation.

WASHINGTON COUNTY

1MMmb Catoctin metabasalt
(2201)

Mostly basaltic lava flows altered to cholritic greenstone with distince foliation (schistose structure); fairly dense, slightly porous; interlayered with purple and gray slaty rocks of volcanic origin, variable porosity, and cleavage.

2MMp Loudoun formation
(2202)

Largely dark slate thin-bedded arkosic (feldspathic) quartzite with many interbeds of purer quartzite, schist, thin beds of limestone, and phyllite; some of the quartzite beds, especially those near the base of the formation, are conglomerate with pebbles up to 4 inches in diameter.

3MMq Weaverton quartzite
(2203)

Generally thick bedded, blocky quartzite; locally contains subordinate thin slabby beds. White, gray, and bluish-gray layers; lower beds of the formation are less uniform with arkosic (feldspathic) and conglomerate layers prominent.

4MMp Harpers phyllite
(2204)

Thin-bedded schistose and slaty beds with a prominently developed rock cleavage.

5MMq Antietam quartzite
(2205)

Hard, fine to medium-grained sandston and quartzite; much of it is thin-bedded and readily cleavable into plates and thin slabs, but some beds are thick-bedded and yield blocks more than 6 inches thick.

6Sc Tomstown dolomite
(2206)

Blocky dolomite and dolomitic limestone, and massive thick, white limestone interbeds of sandstone and dense limestone

8Sl Conochocheague limestone
(2208)

Limestone beds of variable composition, mostly high calcium limestone; but includes many beds of dolocitic (magnesiun) limestone, sandy limestone, calcareous shale, shaly limestone, and some thin beds of sandstone. Very thin shaly partings commonly separate the limestone beds, which are usually thin (few inches).

9Sl Beekmantown limestone
(2209)

Generally massive, thick-bedded limestone beds up to 10 or more feet thick; dense to finely crystalline texture; some thin shaly layers (partings). Chert nodules common.

10Sl
(2210)
Stone River limestone

Mostly medium and light gray, dense to finely crystalline thick bedded (massive) limestones; mostly pure, but locally contains thin beds of cherty limestone. Commonly show distince fossil forms. Very thick formation; the middle layers are cherty and the chert fragments appear in the clay soil overburden.

11Sl
(2211)
Chambersburg limestone

Thin-bedded dark bluish-gray fossiliferous limestone with many clay partings; breaks into cobblestone-size fragments and small blocks.

12Sh
(2212)
Martinsburg shale

Very thick formation composed mostly of thin-bedded shales, with very subordinate thin beds of sandstone and, more rarely, of limestone.

13Ssh
(2213)
Tuscarora sandstone and Juniata formation

Hard, white, massive Tuscarora sandstone, and underlying soft, red Juniata sandstone and shale. The white Tuscarora sandstone is tightly cemented, in part quartzite, hard, and of low porosity. The underlying red Juniata sandstone is softer and more porous and includes some shaly beds. In general, the formations are hard, resistant and structurally firm.

14Sh
(2214)
Clinton shale

Predominantly gray, pink, or red shale with thin beds of sandstone, in places quartzite, and a few very thin limestone beds; locally red sandstone up to 30 feet thick, which has an iron content of about 25% and was formerly worked for iron ore.

15Ssh
(2215)
McKenzie formation, and Wills Creek shale

Predominantly interbedded gray, greenish-gray, and red shale, shaly sandstone, and calcareous shale, with thin beds of argillaceous limestone and soft sandstone.

16Sl
(2216)
Helderberg limestone and Tonolway limestone

Predominantly limestone beds, mostly bluish-gray, massive; thin bedded, shaly and cherty limestone and calcareous shale, with few thin beds of sandstone.

17Ss
(2217)
Oriskany sandstone

Calcareous sandstone, much of which is coarse-grained or conglomeratic; locally subordinate beds of sandy limestone; cemented chiefly by calcite (calcium carbonate), but some beds cemented by quartz to form quartzite and are consequently harder and less porous than the rest. In a few places the amount of calcite exceeds the amount of quartz grains, making an arenaceous (sandy) limestone.

18Sh Romney shale
(2218)

Dark gray and black (carbonaceous) shale, and sandy shale, with several thick-bedded layers of sandstone.

19Ssh Jennings formation
(2219)

Greenish-gray sandy shale with thin beds of conglomerate and of sandstone, especially in upper part; in part black (carbonaceous) shale.

20Ssh Catskill (Hampshire) formation
(2220)

Mixed sandstone and shale, mostly "red beds," some greenish-gray shales.

21Ssh Rockwell and Purslane formations
(2221)

Mixed shale, sandstone, and conglomerate beds; thin coal beds.

22AF Alluvial Mountain Wash
(2222)

Extensive alluvial cones and fans composed of gravels and sands of greatly variable texture, including many boulders and cobbles; generally coarser-textured toward the mountain slopes. Pebbles chiefly quartzite, but many slaty fragments are included.

23AT Terrace gravels
(2223)

Gravel and sand of alluvial origin. Cobbles and large pebbles are abundant; thickness of deposits variable; generally not greater than 25 feet.

24AR Alluvium
(2224)

Flood plain fine sand, silt, and clay with included thin layers and lenses of fine gravels along Potomac River.

WICOMICO COUNTY

*2301 Undifferentiated sands, clays and gravel.

Gray to buff sand and gravel, gray to brown lignitic silt and clay, occasional boulders, includes surficial deposits that occur as intercalated fluvial sands and marsh muds; well sorted, stabilized dune sands, shell bearing estuarine clays and silts, and beach zone sands, also subsurface deposits of pre-Wisconsin age, buff to reddish-brown sand and gravel.

2302 Manokin Aquifer

Shows area influenced by aquifer recharge in the materials in 2301.

2303 Pocomoke Aquifer

Shows area influenced by aquifer recharge in the materials of 2301.

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*No letter-number symbol available because map not produced in 1965.

WORCESTER COUNTY

*2401 Undifferentiated sands, clays and gravel.

Gray to buff sand and gravel, gray to brown lignitics silt and clay, occasional boulders, includes surficial deposits that occur as intercalated fluvial sands and marsh muds; well sorted, stabilized dune sands, shell bearing estuarine clays and silts, and beach zone sands, also subsurface deposits of pre-Wisconsin age, buff to reddish-brown sand and gravel.

2402 Pocomoke Aquifer

Shows area influenced by aquifer recharge in the materials of 2401.

*No letter-number symbol available because map not produced in 1965.

THE DIFFERENT CHARACTERISTICS DESCRIBED IN TABLE 3 ARE DEFINED AS FOLLOWS:

HARDNESS: Refers mainly to the resistance of the rock to being scratched or sawed. The rocks in this table have been classified as

Hard, Medium or Soft. All the unconsolidated sediments are classified as soft. It should be noted, however, that there is a great deal of difference between a soft rock and an unconsolidated sediment.

EXCAVATION REQUIREMENTS: States whether blasting or power equipment, i.e. ripping or power shovel, is necessary to remove fresh rock.

EXTENT OF ROCK WEATHERING: Refers to the amount of physical and chemical weathering that has taken place on a rock. The amount of weathering depends on the following: 1.) the length of time the rock has been exposed to weathering and the severity of the climate; 2.) the ability of the rock to resist weathering; and 3.) the rate at which the weathered material (soil) is carried away. The terms Pronounced, Moderate, Slight and Variable plus short explanatory phrases, have been used to describe the extent of weathering.

DURABILITY OF FRESH ROCK: A measure of the rock's ability to withstand weathering. The relative degrees of durability are given by the terms: Good, Fair and Poor.

DIP OF PROMINENT LAYERING: Refers to the angle between the horizontal and the plane of stratification, in the case of sedimentary rocks, or the angle between the horizontal and the plane of schistosity, in the case of the metamorphic rocks. Values of the angle of the bedding plane with the horizontal plane are given when known, otherwise the following terms are used: Horizontal, Gentle, Moderate, Steep and Variable.

STABILITY OF CUT FACES: Refers to the ability of rock cuts to maintain stable faces, so that falling rock will not be a problem. The general terms used in this column are Good, Fair, Poor, Unstable and Variable. Additional comments also appear in the table.

OVERBURDEN THICKNESS: Refers to the depth of soil cover before weathered rock is reached. The depth in feet is given where information was available. The terms Thick, Moderate, Thin and Variable are used otherwise.

BOULDERS: Refers to the occurrence of boulders, or large blocks of partially weathered stone. Terms used to describe the presence of boulders: Some, Few, Rare and None.

REMARKS: Gives any additional information which will aid in the engineering interpretation of the rock formation.

Table 3

ENGINEERING CAPABILITY OF EACH GEOLOGIC FORMATION BY COUNTY

Allegany County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0101	Medium	Slight	Poor	Thin	Variable	
0102	Hard	Slight	Very good	Very thin	Moderate	
0103	Soft	Slight to moderate	Poor	Locally thick	Moderate	
0104	Variable - medium to soft	Variable	Poor	Thin in places	Moderate to low	
0105	Medium to hard	Moderate	Good	Variable - thick in part		
0106	Chert layers - hard; sandstone medium	Slight	Chert beds - good; sandstone-poor	Thin	Variable - moderate to steep	Nodules of chert
0107	Soft	Slight to moderate	Poor	Thin		None
0108	Variable - mostly soft	Slight	Generally poor, except quartzite beds	Usually thin		Blocks of quartzite in places
0109	Variable - hard to soft	Slight	Variable. Sandstone-good; shales-poor	Thin, but locally thick where	Variable - usually low to moderate	Blocks of sandstone numerous
0110	Variable-thick bedded portions harder than others	Slight	Massive beds-fair to good	Thin; locally thick cover of soil creep	Moderate to steep	

Allegany County (con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0111	Hard	Moderate	Fair	Thin to thick according to amount of soil creep	Moderate	
0112	Soft	Slight	Poor	Variable-generally thin	Moderate	Rare
0113	Medium	Slight	Good for massive beds of sandston sandstone	Thin, generally only a few feet	Moderate	
0114	Sandstone-medium, shales, coals & clays, soft	Variable	Massive sandstone beds-good	Variable - moderate to thick	Gentle	
0115	Medium to soft	Slight to moderate	Poor	Variable - generally thin	Gentle	

Allegany County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0101	Power Equipment; some blasting	Poor	
0102	Blasting	Stable, except along few clayey partings	Difficult excavation due to hardness plus lack of bedding cleavage
0103	Power Equipment	Poor	
0104	Power Equipment; some blasting	Poor-fracture cleavage prominent	
0105	Blasting	Lower thin-bedded parts apt to shear at low angles	Excellent foundations; moderately difficult excavation of thicker beds
0106	Slight	Good	Chert layers-excellent foundation; difficult excavation. Sandstone beds-poor foundations moderately easy excavations
0107	Power Equipment	Poor-tendency to absorb water promoting slippage	Walls of cuts must have low angle and always less than dip of formation.
0108	Power Equipment; blasting for hard beds	Poor	Weak; poor foundation for most part
0109	Power Equipment; some blasting	Sandston-good; shale bed-poor	Cut slopes whould be low in shale beds and always less than angle of dip of beds
0110	Blasting	Apt to slide on platy and shaly layers and partings	

Allegany County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0111	Blasting	Stability-fair to good where dip into slope	Good foundation and difficult excavation
0112	Power Equipment	Unstable	Poor Foundation and easy excavation
0113	Blasting	Good for massive beds of sandstone	Moderately good to good foundation and moderately difficult excavation
0114	Power Equipment: blasting for massive sandstone	Low ability, except thick beds of sandstone	Poor to fair foundation and easy excavation
0115	Power Equipment; some blasting	Poor	Poor foundation and easy excavation

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0201	Soft					
0202	Soft					
0203	Soft					
0204	Soft					Iron nodules common; large boulders rare
0205	Soft					"Ironstone" (Limonite) Concretions
0206	Soft					Small iron concretions common
0207	Soft					
0208	Soft					Rare
0209	Soft					Few large boulders
0210	Soft					Few scattered boulders

Anne Arundel County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0201	Power Equipment		Has been used as source of sand and gravel
0202	Power Equipment		
0203	Power Equipment	Tendency to slump on cut slopes	Poorly drained in most areas, except where thick beds of sand occur at surfact
0204	Power Equipment		Most of the formation's sand beds drain well. Clay beds at or near surface drain poorly
0205	Power Equipment		Lower part predominately sand Upper part predominately clay
0206	Power Equipment		
0207	Power Equipment		Commonly less than 50 ft. thick; may be 100 feet or more in places.
0208	Power Equipment		
0209	Power Equipment		
0210	Power Equipment		

Baltimore County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0301	Hard	Moderate	Good	Thick	Variable	
0302	Variable - medium to hard	Variable generally moderate	Quartzite - good schists-poor	Moderate	Moderate to steep	
0303	Moderately hard	Slight	Good	Very thin	Steep	
0304	Medium to hard	Moderate to pronouned	Fair	Thick	Generally 40° or more	
0305	Soft, except for thin beds of quartzite	Moderate	Poor	Moderate	45° or steeper	
0306	Mostly quartzite-hard; some schists medium	Moderate to pronounced	Good	Thick	Moderate to steep	
0307	Hard	Slight to moderate	Good	Thin		
0308	Medium	Slight	Fair	Thin		
0309	Hard	Moderate	Fair	Thin		
0310	Hard	Slight	Good	Thin		
0311	Hard	Moderate	Good	Thin		
0312	Hard	Generally slight; moderate in prominently foliated portions	Good	Generally thin to moderate; locally thick		

Baltimore County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0313	Soft	Moderate	Good	Thin		
0314	Soft				Essentially horizontal	
0315	Soft					
0316	Soft					
0317	Soft					
0318	Soft					Rare- Usua. less than 12"
0319	Soft					

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0301	Blasting	Good, except where broken along plans of foliation	
0302	Blasting	Some tendency to sheer along foliation	Quartzite layers are hard and more resistant to weathering than are the schist layers
0303	Blasting	Good	
0304	Blasting	Susceptible to shearing at dips about 15° or more toward open faces	Mostly thinly layered rocks that split readily; includes hard layers of quartzite
0305	Blasting	Susceptible to shearing at dips of about 15° or more toward open faces	Mostly thinly layered rocks that split readily; includes of granular gneiss
0306	Blasting	Schist layers shear readily	
0307	Blasting	Good	A tough rock; however, in some places it is broken into small angular blocks
0308	Blasting	Good	Although primarily a soft rock, it commonly is difficult to dril
0309	Blasting	Good	Same general characteristics as gabbro.
0310	Blasting	Good	Along borders of areas the rock includes layers of schist and gneiss and breaks into thin slabs

Baltimore County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0311	Blasting	Good where not highly fractured	Rock is highly fractured in many places where it breaks into small blocks
0312	Blasting	Generally good; will shear in prominently foliated portions	Where the gneissic structure is prominent, the rock commonly breaks into thin slabs
0313	Blasting	Little tendency to shear	Rock has crushing properties and hardness of typical granites
0314	Power Equipment		Used as a source of sand and gravel
0315	Power Equipment	Tendency to slump on cut slopes	Subject to soil flow
0316	Power Equipment		Hardpan locally present where iron oxides have collected
0317	Power Equipment		Sand layers are cemented by iron oxide and silica in places
0318	Power Equipment		Contains thin layers of sand, silt and clay
0319	Power Equipment		Contains thin beds of gravel, silt, and clay; also considers organic matter (Peat beds)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0501	Soft				Essentially horizontal	
0502	Soft				Essentially horizontally	Scattered throughout but not abundant

Calvert County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0501	Power Equipment		Prevailing materials of this group are sandy clays with shells
0502	Power Equipment		Thickness and proportions of gravel, sand, and clay vary markedly from place to place
0503			Swamp or marshland

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0601	Soft	Slight; some beds indurated with iron oxides			Gentle	None
0602	Soft				Gentle	Scattered boulders in all parts of formation
0603	Soft	Slight			Gentle	Scattered

Caroline County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0601	Power Equipment		
0602	Power Equipment		Thickness of formation up to 50 feet, average about 20 feet
0603	Power equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0601	Hard	Moderate to pronounced	Good	Thick in most places		few weathered boulders
0602	Medium	Slight	Fair	Thin		
0603	Hard	Moderate	Good	Variable	Vertical or nearly so	
0604	Hard	Moderate	Good	Thick in most places	Variable	
0605	Quartzite-hard; schist-soft	Variable-generally moderate	Quartzite-good; schist-poor	Moderate	Moderate to steep	
0606	Hard	Pronounced in many places	Good	Variable-locally thick	Steep	
0607	Hard	Variable-fairly pronounced in places	Variable-poor to fair	Locally thick	Moderate to steep	
0608	Soft except for thin beds of hard quartzite and gneiss	Moderate	Poor	Variable	45° or steeper	
0609	Medium to hard	Moderate to pronounced	Fair	Variable	Generally 45° or more	
0610	Mostly quartzite hard; some schist-soft	Moderate to Pronounced	Poor	Thin	Moderate to steep	

Carroll County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0611	Hard	Moderate	Quartzite beds-good	Variable	Moderate	Blocks of quartzite
0612	Hard	Moderate	Good	Variable	Variable-mostly steep to moderate	
0613	Hard	Moderate	Good	Variable	Variable	
0614	Medium	Moderate	Poor	Variable	Gentle	
0615	Soft	Slight to moderate	Poor	Thin	Gentle	

Carroll County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0601	Blasting	good stability	
0602	Blasting	Shears easily along cracks in several directions	Although primarily a soft rock, it is commonly a difficult rock to drill
0603	Blasting	Good	
0604	Blasting	Good, except where broken along planes of foliation	
0605	Blasting	Some tendency to sheer along foliation	
0606	Blasting	Good	
0607	Blasting	Shears where schists layers are present	
0608	Blasting	Susceptible to shearing at dips of 15° or more toward open faces	Mostly thinly layered micaceous rocks which split readily--includes one layer of gneiss
0609	Blasting	Susceptible to shearing at dips of about 15° or more toward open faces	Mostly thinly layered rocks that split readily-includes hard layers of quartzite
0610	Blasting	Schist layer shear readily	
0611	Blasting	Good	Now known as Marburg schist, formerly called loudoun
0612	Blasting	Poor where cleavage dip is appreciable toward open faces	

Carroll County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0613	Blasting	Variable; See "Remarks"	Joint blocks may require removal where dips are toward cut
0614	Power Equipment; Minor blasting	Variable	Lower part of formation is composed mostly of thick beds of conglomerate inter bedded with red sandstone
0615	Power Equipment	Poor	

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0701	Hard	Moderate	Good	Thick	Variable	
0702	Medium to hard	Moderate to pronounced	Fair	Thick	Generally 45° or more	
0703	Hard	Generally slight; moderate in prominently foliated portions	Good	Generally thin to moderate; locally thick		
0704	Hard	Slight to moderate	Good	Thin	Not layered	
0705	Medium	Slight	Fair	Thin		
0706	Hard	Slight	Good	Generally thin		
0707	Hard	Moderate	Good	Variable	Vertical or nearly so	
0708	Soft					
0709	Soft					
0710	Soft					
0711	Soft					
0712	Soft					
0713	Soft					

Cecil County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0714	Variable-mostly soft	Considerable limonite in places				
0715	Soft	Variable; some beds locally cemented by iron oxides				

Cecil County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0701	Blasting	Good, except where broken along planes of foliation	
0702	Blasting	Susceptible to shearing at dips of about 15° or more toward open faces	Mostly thin-layered rocks that split readily-includes hard layersof quartzite
0703	Blasting	Generally good; will shear in prominently foliated portions	Where the gneiss structure is prominent, the rock commonly breaks into thin slabs
0704	Blasting	Good	A tough rock; however, in some places it is broken into small angular blocks by closely spaced joints
0705	Blasting	Shears easily along cracks in several directions	Although primarily a soft rock, it is tough and commonly difficult to drill
0706	Blasting	Generally good, except where obviously shattered	Mostly hard, but brittle rock breaking into sharply angular fragments
0707	Blasting	Good	
0708	Power Equipment		Used for concrete fine and coarse aggregate
0709	Power Equipment		Much of the formation (clay portion) will drain slowly
0710	Power Equipment		Includes parts of the Patuxent and Patapsco formations

Cecil County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0711	Power Equipment		Generally similar to Patapsco except that sand is the dominant material
0712	Power Equipment		Occurs in narrow areas along valley less than 60 ft. above sea level and mostly below 40 ft. M.S.L.
0713	Power Equipment		Thickness about 40 ft. exposed above sea level
0714	Power Eauipment		40 to 100 feet thick; altitudes range from 120 to 300 feet above sea level
0715	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
0901	Soft				Nearly horizontal	
0902	Soft				Nearly Horiztonal	Rare
0903	Soft				Nearly horizontal	Scattered locally; fairly numerous mostly less than 2 feet

Charles County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
0901	Power Equipment		
0902	Power Equipment		Pebbles of the gravel portion are usually less than 2 inches in diameter and are composed of quartz & chert
0903	Power Equipment		
0904			Swamp or marshland

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1001	Soft	Slight			Gentle	Scattered
1002	Soft	Slight			Gentle	Scattered

Dorchester County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1001	Power Equipment		
1002	Power Equipment		Contains Manokin Aquifer

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1101	Hard	Variable	Poor	Thin in many places	Moderate to steep	
1102	Medium	Pronounced	Poor	Variable	Steep	
1103	Hard	Pronounced in many places	Fair to good	Thick in many places		
1104	Hard	Moderate	Quartzite-good; rest-poor	Variable-generally thin	Moderate to steep	
1105	Medium	Slight	Good	Variable-thin on valley floor	Moderate	
1106	Hard	Slight	Good	Thin		
1107	Hard	Variable	Variable-complex	Variable		
1108	Hard	Pronounced on upland areas	Good	Moderate to deep	Steep	
1109	Hard	Slight	Quartzite-good	Thin	Variable-mostly greater than 30°	
1110	Hard	Slight	Good	Very thin	Steep	
1111	Medium	Slight	Poor	Thin-see remarks	Steep	See remarks
1112	Hard	Moderate	Fair	Thin	Variable	
1113	Hard	Slight	Good	Very thin	Variable	

Frederick County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1114	Medium	Moderate	Poor	Variable-probably less than 10 feet	Variable-generally steep	Platy segments in soil
1115	Medium	Variable	Good	Clay probably less than 15 ft. in many places	Variable-steep in many places	Limestone boulders just above bedrock
1116	Medium	Moderate	Fair to good	Usually thin	Moderate	
1117	Medium	Moderate	Poor	Variable	Gentle	
1118	Soft	Slight to moderate	Poor	Thin	Gentle	
1119	Hard	Pronounced	Good	Moderate to steep	Dikes are vertical; sills are horizontal	
1120	Soft					Few
1121	Soft					
1122	Soft					

Frederick County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1101	Blasting	Poor	
1102	Power Equipment; some blasting	Poor	
1103	Blasting	Fair	
1104	Blasting	Poor	
1105	Blasting	Fair	
1106	Blasting	Good	Outcross will shatter into small blocks when blasted
1107	Blasting	Variable	Rock types diverse and variable and intricately mixed in most areas
1108	Blasting	Variable	
1109	Blasting	Quartzite-good; slate and schist-poor	
1110	Blasting	Good	
1111	Blasting	Poor	Covered by thick debris of quartzite blocks from adjacent ridges, in many places
1112	Blasting	Fair	
1113	Blasting	Good	
1114	Blasting	Poor	Thin beds with shaly partings

Frederick County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1115	Blasting	Good, except for fractured tops beds in places	Locally weathers to a porous sandstone
1116	Blasting	Good	Has been used as an ornamental and interior finish "marble"
1117	Power equipment; some blasting	Variable	Lower part of formation is composed mostly of thick beds of conglomerate interbedded with red sandstone
1118	Power Equipment	Poor	
1119	Blasting	Good	Fresh stone is excellent for crushed aggregate
1120	Power Equipment		Variable proportion of pebbles and sand matrix
1121	Power Equipment		Deposits above water level are very thin.
1122	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1201	Mostly soft, but sandstone beds hard	Slight	Good	Thin	Steep	Some small blocks
1202	Moderate	Slight	Good	Variable-usually thin	Moderate	
1203	Variable-thick bedded portions harder than others	Slight	Massive beds-fair to good	Thin-locally thick cover of soil creep	Moderate to steep	
1204	Medium	Variable-generally a few feet	Fair to good	Usually a few feet	Moderate	
1205	Medium	Slight	Good	Generally thin	Moderate	
1206	Medium	Slight	Good for massive beds of sandstone	Thin-generally only a few feet	Moderate	
1207	Sandstone-medium shales, coals & clay-soft	Variable	Massive sandstone beds good	Variable-moderate to thick	Gentle	
1208	Medium to soft	Slight to moderate	Poor	Variable-Generally thin	Gentle	

Garrett County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1201	Power Equipment; some blasting	Unstable in cuts where dips is toward cut	Moderately durable foundation moderately difficult excavation
1203	Blasting for thicker sandstone beds	Cut slopes less than 45° where beds dip into cuts	Moderately difficult to excavate, sandstone beds up to 20 feet thick
1204	Blasting	Apt to slide on platy & shaly layers and partings	
1204	Blasting	Good in upper limestone beds; variable in shaly beds	Easy to moderately difficult excavations
1205	Blasting for thicker bedded portions	Requires low slopes where bedding is inclined appreciable toward cut	Poorly drained; may require permeable drainage material
1206	Blasting	Good for massive beds of sandstone	Moderately difficult excavation
1207	Blasting for massive sandstone	Low stability except thick beds of sandstone	
1208	Power Equipment; minor blasting	Poor	

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1301	Hard	Moderate	Good	Thick	Variable	
1302	Mostly quartzite hard; some schist-medium	Moderate to pronounced	Poor	Thick	Moderate to steep	
1303	Hard	Slight	Good	Very thin	Steep	
1304	Medium to hard	Variable-may be deep	Poor	Variable	Variable	
1305	Hard	Slight	Good	Thin	Steep	
1306	Hard	Slight	Good	Thin	Steep	
1307	Medium	Slight	Good	Thin		
1308	Hard	Slight to moderate	Good	Thin	Not Layered	
1309	Hard	Generally slight; moderate in prominently foliated portions	Good	Thin	Variable-generally steep	
1310	Hard	Moderate	Good	Variable	Dikes are nearly vertical	
1311	Soft				Essentially horizontal	
1312	Soft			Thin	Essentially horizontal	

Harford County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1313	Soft				Essentially horizontally	few large boulders
1314	Soft					
1315	Soft					

Harford County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1301	Blasting	Variable; good except where broken along plans of foliation	
1302	Blasting	Schist layers shear readily	
1303	Blasting	Variable	
1304	Blasting	Poor; shears readily on foliation planes	
1305	Blasting	Good stability	A hard, massive formation, may be covered by soil creep and talus materials from state outcrop above.
1306	Blasting	Variable; shears readily along cleavage planes	
1307	Blasting	Shears easily along cracks in several directions	Although primarily a soft rock, it commonly is difficult to drill
1308	Blasting	Does not shear readily	A tough rock, however, insome places it is broken into small angular blocks
1309	Blasting	Generally good	In border areas rock is apt to break into thin slabs
1310	Blasting	Good stability	
1311	Bulldozer		Used for concrete coarse & fine aggregate

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1312	Bulldozer	Tendency to slump on cut slopes	Subject to soil flow
1313	Power Equipment		Areas in central part of county consist of sand and gravel. Sand and silt more common in southern part.
1314	Power Equipment		Drainage generally good
1315	Power Equipment		Contains thin beds of gravel silt and clay. Contains considerable organic matter as peat beds

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1401	Hard	Variable	Good	Moderate	Steep	
1402	Medium to hard	Generally moderate	Quartzite-good; schists-poor	Thick	Moderate to steep	
1403	Medium to hard	Slight	Good	Thin	Steep	
1404	Medium to hard	Moderate to pronounced	Fair	Thick	Generally 45° or more	
1405	Quartzite and gneiss-hard; schist and phylitte-soft	Moderate	Poor	Moderate	45° or steeper	
1406	Mostly quartzite good; some schist-medium	Moderate to pronounced	Low	Thick	Moderate to steep	
1407	Medium to hard	Moderate	Good	25 ft. in upland area	50° - 90°	
1408	Hard	Slight to moderate	Good	Thin	Not layered	
1409	Medium	Slight	Fair	10 feet +		
1410	Mostly hard	Moderate	Good in part; thinly layered portions are poor		Generally steep	
1411	Hard	Moderate	Good	Thin	None	

Howard County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1412	Hard	Moderate	Good	Variable	Steep	
1413	Hard	Pronounced	Good	20 feet in upland	Dikes nearly vertical	
1414	Soft					

Howard County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1401	Blasting	Fair to good. Tendency for joint blocks to slide	
1402	Blasting	Will shear along foliation planes	
1403	Blasting	Good	
1404	Blasting	Poor where dip is toward open faces	Mostly thinly layered rocks that split readily-includes some hard layers of quartzite rock
1405	Blasting	Poor where dip is toward open faces	Mostly thinly layered micaceous rocks which split readily - includes some layers of coarse granular rocks
1406	Blasting	Schist layers shear readily	
1407	Blasting	Will sustain steep cuts except in thin layered portions	
1408	Blasting	Good	A tough rock; however, in some places it is broken into small angular blocks by closely spaced joints
1409	Blasting	Locally shears easily along contacts and fractures, when wet	A tough rock which is commonly difficult to drill
1410	Blasting	Schist portions will shear	

Howard County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1411	Blasting	Good where not highly fractured	Rock is highly fractured in many places where it breaks into small blocks
1412	Blasting	Good	
1413	Blasting		Fresh stone is excellent for crushed aggregate
1414	Power Equipment		Used locally for sand and gravel

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1501	Soft				Nearly Horizontal	Locally large iron-bearing concretions
1502	Soft				Nearly horizontal	
1503	Soft				Nearly horizontal	
1504	Soft				Nearly horizontal	Scattered various sizes

Kent County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1501	Power Equipment		
1502	Power Equipment		
1503	Power Equipment		
1504	Power Equipment		

Montgomery County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1601	Medium to soft	Moderate to pronounced	Fair	50+ feet	Generally 45° or more	
1602	Soft to medium except for occasional beds of hard quartzite	Moderate	Poor	10 to 30 feet	45° or steeper	
1603	Hard	Moderate	Fair	10 to 20 feet	None	
1604	Hard in most places	Moderate	Good in part; thinly layered portion poor	Generally 20 ft. some locations up to 60 feet	Generally steep	
1605	Medium to hard	Moderate	Good	25 feet in inland areas	50° to 90°	
1606	Hard	Moderate	Good	0 to 25 ft; thicker on flat divides		
1607	Medium	Slight	Fair	10+ feet		
1608	Hard	Pronounced	Good	20+ feet in upland areas	Dikes are vertical sills dips 5-10° west	
1609	Medium to soft	Slight	Sandstone-fair; shales poor	10-30 feet	5 to 25° waterly	
1610	Hard	Moderate	good		Steep	

Montgomery County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1611	Hard	Variable	Poor	Thin in many places	Moderate to steep	
1612	Soft				Essentially horizontal	
1613	Soft				Essentially horizontal	
1614	Soft					Small boulders in few places
1615	Soft					Rare

Montgomery County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1601	Blasting	Susceptible to shearing at dips of about 15° or more toward open faces	Mostly thin layered rocks that split readily - includes some hard layersof quartz rock
1602	Blasting	Susceptible to shearing at dips of about 15° or more toward open faces	Mostly thin layered micaceous rocks that split readily-includes some layers of coarse granular rocks
1603	Blasting	Rock will break into blocks rather than slabs	Tough granualar rocks
1604	Blasting	Schist portions will have tendency to shear	Variable but mostly hard granitic rocks
1605	Blasting	Will sustain steep cuts in most places	Thinly layered portions are subordinate and will break into thin slabs
1606	Blasting	Will sustain steep cuts in most places	Closely jointed in a few places yielding unstable blocks in cuts
1607	Blasting	Shears easily along contacts and fractures when	A tough rock which is usually difficult to drill
1608	Blasting		Fresh stone is excellent for use as crushed aggregate
1609	Some blasting for sandstone portions		Relatively high porosity; may contain considerable water
1610	Blasting	Rock will break in block	Drilling may be difficult

Montgomery County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1611	Blasting	Poor	
1612	Power Equipment		Used locally as source of material by sand and gravel industry
1613	Power Equipment	Tendency to slump on cut slopes	Soil subject to solifluction
1614	Power Equipment		
1615	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1701	Soft				Essentially horizontal	
1702	Soft				Essentially horizontal	
1703	Medium to hard	Moderate	Good	25 feet in upland areas	50° to 90°	
1704	Soft				Gentle	
1705	Medium to soft				Gentle	Hard pan
1706	Soft				Gentle	None
1707	Soft				Gentle	None
1708	Soft				Gentle	Few
1709	Soft				Variable	Few; locally up to 18 inches
1710	Soft				Gentle	Few large cobbles
1711	Soft				Gentle	

Prince George's County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1701	Power Equipment		Used locally for concrete coarse and fine aggregate
1702	Power Equipment	Tendency to slump on cut slopes	Subject to soil solifluction
1703	Blasting	Will sustain steep cuts	
1704	Power Equipment		
1705	Power Equipment		Formation is locally cemented by $CaCO_2$ (Marl), these beds may require ripping
1706	Power Equipment		
1707	Power Equipment		
1708	Power Equipment		
1709	Power Equipment		
1710	Power Equipment		
1711	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1801	Soft	Slight, some beds indurated with iron oxides			Gentle	None
1802	Soft				Gentle	Scattered boulders in all parts of formations
1803	Soft	Slight			Gentle	Scattered

Queen Anne's County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1801	Power Equipment		
1802	Power Equipment		
1803	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
1901	Soft			Thin loam	Gentle	None
1902	Soft	Up to 20 feet; oxidation to brown clay			Gentle	None
1903	Soft	Moderate; locally weathered to depth of a few feet			Gentle	Scattered boulders through out, but not abundant

St. Mary's County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
1901	Power Equipment		The gentle dip to southeast brings the group entirely below sea level in southern part of county
1902	Power Equipment		Thickness up to 30 feet
1903	Power equipment		Exposed thickness about 40 feet in northern part of county increasing gradually to 130 feet in southern part.

Somerset County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2001	Soft	Slight			Gentle	Scattered
2002	Soft	Slight			Gentle	Scattered

Somerset County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2001	Power Equipment		
2002	Power Equipment		Contains Pocomoke Aquifer

Talbot County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2101	Soft	Slight; some beds indurated with iron oxides			Gentle	None
2102	Soft				Gentle	Scattered boulders in all parts of formation
2103	Soft	Slight			Gentle	Scattered

Talbott County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2101	Power Equipment		
2102	Power Equipment		Thickness of formation up to 50 feet, average about 20 ft.
2103	Power Equipment		

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2201	Variable Medium to hard	Deep in upland area	Good	Moderate to deep	Steep	
2202	Hard	Slight	Quartzite good	Thin	Variable-mostly greater than 30°	
2203	Hard	Slight	Good	Very thin	Steep	
2204	Medium	Variable-fairly deep in many places	Poor	Thin	Steep	
2205	Hard	Slight	Good	Thin	Moderate to steep	Thin slab by blocks numerous
2206	Medium to hard	Moderate to deep	Good	Variable-thick in valleys with pinnacles of limestone	Moderate	Pinnacles of bedrock
2207	Soft	Moderate	Poor	Variable	Steep; greatly folded and sheared	
2208	Medium	Variable	Poor	Variable-fairly thick	Mostly moderate to steep	Small boulders
2209	Hard	Deep	Good for massive beds	Variable-commonly thick		
2210	Hard	Moderate to deep	Good	Variable		

Washington County (Con't)

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2211	Medium	Moderate	Poor	Thin to moderate	Moderate	Cobbles and blocks at surface
2212	Soft	Slight	Poor	Thin	Variable	None
2213	Medium to hard	Slight	Good	Vary thin	Steep	
2214	Variable Shale	Slight	Poor	Generally thin	Moderate to steep	
2215	Variable medium to soft	Variable	Poor	Thin in places	Moderate to low	
2216	Variable-generally hard	Variable deep in places	Good	Variable-generally moderate, deep red clay in places	Variable commonly 30° to 60°	
2217	Quartzite beds hard; calcerous	Variable deep in places	Quartzite-good; càlcite beds poor	Very thin over quartzite beds	Commonly 40° to 60°	
2218	Soft	Moderate	Poor	Variable generally thin	Variable	
2219	Medium	Slight	Poor	Generally thin	Variable-commonly 40° to 75°	
2220	Medium	Slight	Good	Thin	Usually 30° to 50°	Scant small blocks of sandstone

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2221	Medium	Slight	Fair	Thin	Moderate 25°-50°	
2222	Soft					
2223	Soft					
2224	Soft					Few

Washington County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2201	Blasting	Variable	
2202	Blasting	Quartzite-fair; slate and schist-poor	
2203	Blasting	Good	
2204	Blasting	Generally unstable	
2205	Blasting	Variable-poorest in thin bedded portions	
2206	Blasting	Variable; loose rocks	Weathers to red clay soil
2207	Power Equipment; minor blasting	Poor	
2208	Blasting	Poor, owing to shaly partings	Breaks into small blocks and thin slabs; exposures commonly display a "banded" or "ribbon" structure
2209	Blasting	Thicker bedded portions are good	Weathered surfaces show thin irregular clay seems in relief
2210	Blasting	Good	Generally a high calcium, nearly pure limestone, weathers to red clay
2211	Blasting and power equipment	Unstable	Weathers to nodular masses
2212	Power Equipment	Very unstable	For the most part, the rock is easily excavated

Washington County (2) (Con't)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2213	Blasting	Good	
2214	Blasting	Shales-poor; sandstone beds-good	
2215	Power Equipment; some blasting	Poor-fracture cleavage prominent	
2216	Blasting	Massive bed good shaly beds are poor	
2217	Blasting	Some beds crumble in excavating	The calcareous beds weather to form a sand cover, several feet thick in places
2218	Power Equipment	Poor	Easily excavated
2219	Power Equipment; some blasting	Poor	Generally easy excavation except sandstone and conglomerate beds which are difficult
2220	Blasting	Fair to poor	Moderately difficult excavation
2221	Power Equipment; some blasting	Sandstone-stable; shale-poor	Excavation easy to moderately difficult
2222	Power Equipment		
2223	Power Equipment		
2224	Power Equipment		Deposits above water table are very thin

Wicomico County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2301	Soft	Slight			Gentle	Scattered
2302	Soft	Slight			Gentle	Scattered
2303	Soft	Slight			Gentle	Scattered

Wicomico County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2301	Power Equipment		
2302	Power Equipment		Contains Manokin Aquifer
2303	Power Equipment		Contains Pocomoke Aquifer

Worcester County

SYMBOL	HARDNESS	EXTENT OF ROCK WEATHERING	DURABILITY OF FRESH ROCK	OVERBURDEN THICKNESS	DIP OF PROMINENT LAYERING	BOULDER
2401	Soft	Slight			Gentle	Scattered
2402	Soft	Slight			Gentle	Scattered

Worcester County (2)

SYMBOL	EXCAVATION REQUIREMENTS	STABILITY OF CUT FACES	REMARKS
2401	Power Equipment		
2402	Power Equipment		Contains Pocomoke Aquifer

D. Glossary

ACIDIC: A term commonly applied by geologists to igneous rocks that contain a relatively high amount of silica (Sio_2), as indicated either by the presence of quartz of the dominance of other high silica minerals. (Ex. granite, rhyolite, et al.) See also basic rocks.

ALBITE: (See under feldspar.)

ALLUVIUM (adj., alluvial): A general term for sedimentary deposits of stream origin. Alluvium varies in texture from coarse gravels to muds, according to the site of deposition, strength of stream flow, etc.

AMORPHOUS: Without definite form, non-crystalline. Generally applied to minerals of colloidal origin, but sometimes erroneously applied also to microcrystalline material.

AMPHIBOLE: Name given to a group of minerals, of which hornblende is the most common species (see hornblende).

ANTICLINE: (See under Folds.)

APHANITIC: (See under Dense.)

APROHYOLITE: Old thyolite whose ground mass, once glassy, is now devitrified giving a dense extremely fine-grained or non-granular appearance; rare.

ARENACEOUS: Sandy, containing abundant fragmental grains of sand-size. The arenaceous sediments and sedimentary rocks comprise the *sandstones*, in which the dominant clastic mineral grains are within the technical range of sand sizes (Wentworth scale 0.02 to 2.0 millimeters in diameter). However, the term is also applied as a qualifying adjective to other sedimentary rocks that contain subordinate grains of sand, as arenaceous shale (sandy shale), arenaceous limestone (sandy limestone). The sand grains most commonly are quartz, but rarely, sandstones may contain fragments of other rocks within the sand size range (graywacke), or of calcareous minerals, chiefly calcite (calcarenyte).

ARKOSE (adj., arkosic): A sedimentary rock of the sandstone group in which clastic grains of feldspar are a prominent constituent. Technically, by definition an arkose contains at least twenty-five percent of clastic feldspar grains; if less than this amount the rock would be designated *arkosic sandstone*, or *feldspathic sandstone*.

ASBESTIFORM: A mineral form consisting of a crystalline aggregate of slender fibers, like asbestos.

ATTITUDE: The position and orientation in space of a geologic plane, such as a joint, fault, or bedding plane. The attitude of such a plane is described in terms of strike, or compass direction of a horizontal line in the plane, and of dip, or angle between the plane and a horizontal plane. The strike is expressed in terms of compass orientation in reference to true north, as north thirty-five degrees east, north fifty-seven degrees west, east-west, etc. The dip, or angle of inclination, is the maximum vertical angle as measured downward from the horizontal plane, as twenty-seven degrees, forty-five degrees, seventy-six degrees, etc. A symbold expressing dip and strike takes the following form: N35°E27°SE means strike 35° east, dip 27°, on the southeast side of the plane. The dip of a vertical plane may be indicated as 90°, or by the letter V, as N57°W,90 or N57°W,V. A horizontal plane has, of course, no strike symbol.

AUGITE: The most common member of a group of minerals, pyroxene group, chiefly silicates of calcium, magnesium, iron and aluminum. Augite closely resembles hornblende in color, hardness, and prismatic form, but is characterized by cleavage planes approximately at right angles. Augite occurs chiefly in dark crystalline igneous rocks, rarely in schists and gneisses.

BASALT: A dense textured dark gray to black igneous rock.

BASIC ROCKS: Rocks of igneous origin containing relatively large amounts of the basic elements iron and magnesium, and relatively low amounts of silica. Examples: diabase, gabbro, basalt, et al. Such rocks tend to weather rather rapidly, yielding considerable limonite (hydrous iron oxides) and clay; the resulting clayey soil usually has a deep brown color, and the weathered boulders tend to have deep-brown, porous crusts.

BATHOLITH: A large mass of granitoid igneous rock intruded into pre-existing formations in a cross-cutting relationship. Technically a batholith has a surface area of exposure of forty square miles or more; those masses of smaller size are called stocks. Many stocks are knoblike projections of otherwise unexposed batholiths. Batholiths are commonly conceived as widening at depth and to be "bottomless", in contrast with other types of intrusives, but the exact shapes of batholiths at great depths are rarely known; some may gradually taper downward. Because of the uncertainty regarding the shapes of the deep parts of batholiths, many geologists now use the term pluton, which signifies only the deep origin of the mass.

BEDROCK: Consolidated rock in place, as in outcrops of ledge and the formations that everywhere underlie the unconsolidated materials (soil, etc.) of the upper part of the lithosphere.

BIOTITE: (Black mica); A black mineral of the mica family possessing a perfect cleavage and exhibiting surfaces of high luster. Recognized by its color, luster, flaky cleavage and hardness (easily scratched by steel and commonly by finger nail). Biotite has a complex composition, being chiefly a silicate of potassium, magnesium, iron, and aluminum, with some combined water. In weathering it first becomes bleached and oxidized to a yellow-bronze color (sometimes mistaken for flakes of gold), and subsequently yields clay and brown iron oxide (limonite). Biltite is chiefly a constituent of many granitic rocks, gneisses, and schists. Minute flakes of biotite or of the bronze colored weathering products are common in sands and sandstones, and residual soils.

BOULDER: A rounded or partly rounded rock fragment more than ten inches in maximum dimension.

CALCITE: A common mineral composed of calcium carbonate ($CaCO_3$). Calcite is commonly white or gray, may be scratched easily by steel, displays good, lustrous, cleavage planes, and efferveses freely with dilute hydrochloric or acetic acids, (or strong vinegar). It is the chief and essential constituent of limestone, and is commonly present in small amounts in weathered rocks and soils that contained calcium-bearing minerals. The acid test is diagnostic of its presence.

CHERT: A dense variety of quartz, compact and massive like flint but usually light colored. Occurs chiefly as nodules or small lenticular masses in limestone, and as pebbles in some gravels, Some cherts appear to be reactive in some alkali cements, so that gravels which contain prominent amounts of chert may be unsuitable for aggregates in high-alkali cements.

CHLORITE: A green, micaceous mineral composed of magnesium, silica, and water. The thin mica-like sheets or flakes are flexible, but are not elastic as are true micas. Characteristic of some schists in which the mineral may predominate, as chlorite schist, and also as microscopic alterations of other minerals; the mineral imparts a greenish color to such rocks.

CLASTIC: Fragmental. Clastic rocks are composed of fragments of minerals or rocks integrated by natural cementation, incontradistinction from crystalline rocks, which are integrated by crystallization of the grains; crystalline rocks thus have an interlocking crystalline texture.

Common clastic rocks are: conglomerate, sandstone, shale, some limestones (calcarenytes), breccias (coarse angulare fragments as opposed to rounded pebbles.

CLAY: Very fine-grained unconsolidated materials of appreciable, but variable plasticity; of finer texture than silt. In the AGI classification it includes materials composed predominantly of particles less than 0.002 mm diameter; in the Wentworth system, particles less than 1/256 mm diameter. As used in these reports the term is only approximate and is not based on actual measurements; it includes the finest materials that possess an appreciable degree of plasticity.

A rough test for clay is to rub some of the material in the palm of the hand; silt ordinarily brushes or rubs off readily, whereas clay particles ordinarily adhere.

Clays are composed primarily of the so-called "clay minerals", namely, microscopically flaky minerals composed of combined water, alumina, and silica. Principal clay minerals (mineralogical koalin group) are kaolinite, halloysite, beidellite and montmorillonite, which owing to their slightly different crystalline structures, possess different degrees of plasticity, absorption, and shrinkage; they consequently differ in relative stability where wetting is involved. Montmorillonite beidellite, and halloysite clays are least stable and tend to flow and slip readily when wet. The stability properties of clays can be adequately determined only by laboratory tests, though a rough judgement may commonly be made by comparing the slope angles of old and fresh cuts.

CLEAVAGE: The property of a mineral or rock to break or split along definite plane directions. In a mineral the cleavage is a distinctive feature and relates to definite crystallographic planes; some minerals, such as mica, possess one direction of perfect cleavage; other minerals possess two, three, four, or six directions, all of which, in each case, relate to the crystal forms of the mineral.
In a rock, cleavage is determined by the parallel orientation of one of more platy, prismatic, or tabular grains of constituent minerals, or may be a direction of breaking induced by deformation that formed minute insipient parallel fractures (see also fracture cleavage)

COBBLE: A rounded or partly rounded rock fragment from 2½ to 10 inches in maximum dimension.

COLLUVIAL: (Adjective) Consisting of alluvium in part and also containing angular fragments of the original rocks; contrasted with alluvial. Also called talus and cliff debris.

COLLUVIUM: A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity. (AGI)

CONCORDANT: The structural relationship between a sheet of igneous rock and the enclosing strata, in which the sheet lies parallel with the bedding or layering of the enclosing sedimentary strata. Ex., sills, and some lava flows, where extruded upon undeformed, horizontal strata.

DENSE: A textural term applied to igneous and metamorphic rocks in which the individual crystalline grains are not distinguishable by the unaided eye. Characteristic of such rocks as diabase, "trap", slate, and others. Also called aphanitic texture, especially when applied to igneous rocks.

DIABASE: A textural term commonly applied to certain dark-gray to black igneous rocks, commonly the varieties known to petrologists as gabbro, basalt, and "trap", to which varieties the term is often and erroneously applied as a varietal name. See also basalt; trap.

DIKE: A tabular, sheet-like body of igneous rock intruded into other rocks along joint or fault planes; transects the stratification of sedimentary rocks or the foliation of metamorphic rocks. A dike may be a few inches to many feet wide, and the wider dikes are commonly traceable for long distances.

DIMENSION STONE: Stone quarried for use as blocks, slabs, or plates, either rough of finished, to meet dimensional needs; in contrast with crushed or broken stone.

DIP: The angle of inclination of a geologic plane, such as a bedding plane, fault plane, joint, or contact of an igneous rock body. The dip angle is the angle of inclination between the geologic plane and a horizontal plane. The dip, or dip angle, is always measured in a vertical plane perpendicular to the strike direction of the geologic plane. See strike, and attitude.

DISCORDANT: The structural relationship between an intrusive body of igneous rock and enclosing formation, in which the igneous body cuts across the layering or other primary structural features of the intruded formations. Ex., dike, stock, batholith. Cf., concordant.

DOLOMITE: A common mineral composed of the double carbonate of calcium and magnesium, i.e., $CaCO_3.MgCO_3$.

Dolomite is commonly white or gray and softer than steel. It effervesces when powdered and treated with dilute hydrochloric, nitric, or acestic acids (compare calcite).

The term dolomite is applied also to certain sedimentary rocks of the limestone group that are composed of the mineral dolomite; to avoid confusion in terminology, many geologists now give the name dolostone to such rocks.

Compositional gradations exist between pure limestone and dolostone; intermediate varieties are called magnesium limestone or dolomitic limestone.

Dolostone and dolomitic limestones commonly weather to a buff or brown color, owing to the usual presence of a small amount of iron carbonate, an impurity.

DOLOSTONE: See under dolomite.

ELUVIAL (adjective): 1. Formed by the rotting of rock in place to a greater or less depth (USGS Bulletin 26).

2. A term applied to materials carried to lower depths by descending vadose waters, that is, water seeping downward from the surface to the water table.

ELUVIUM (Adjective, eluvial): Atmospheric accumulation in situ, or at least only shifted by wind, in distinction to alluvium, which requires transportation by water.

EXTRUSIVE ROCK: An igneous rock that has been formed on the surface, as a lava flow, in contradistinction to an intruded igneous rock (see intrusiv

FACIES: General appearance or nature of one part of a rock body or stratigra unit as contrasted with other parts, as, the chlorite-schist facies or th quartzite facies of the Wissahickon formation.

FAULT: A plane or surface of fracture in a formation or sequence of formatio along which there has been a relative displacement of the rocks on either side. Cf., joint.

The attitude of a fault plane is described in terms of strike and dip (see attitude).

The more common and general types of faults are: Normal (gravity) fault; an inclined fracture along which the rocks above the fracture have apparen moved downward in relation to rocks beneath. Reverse fault; an inclined fracture along which the rocks above the fracture along which the rocks above the fracture have apparently moved upward in relation to rocks beneath. Thrust or overthrust; reverse fault of low dip angle, that is, less than 45 degrees.

The direction of movement along a fault plane may be at any angle from

0° (horizontal) to 90° (vertical).
Many faults are zones comprised of several closely spaced fractures along each of which there has been displacement; fault zone.
Faults are recognized in the field by the abrupt termination of one formation against another.

FELDSPAR: A group name for certain common rock-forming minerals composed of silica, alumina, potassium, sodium, and calcium in various proportions. The feldspars are harder than steel, possess two good cleavage planes at approximately right angles, and are variously colored, chiefly white, gray, or pink. Varietal names are based on relative contents of sodium, potassium, and calcium. Thus, orthoclase (microcline) is potassium feldspar; plagioclases are sodium-calcium feldspars.
Feldspars are principal and essential constituents of granites and certain other granitoid rocks, and granitic gneisses, and are commonly present in mica schists; detrital grains are commonly found in sands derived from such rocks (see arkose).

FOLDS: Wrinklings or plications of stratified rocks, caused by compressional, approximately tangential forces. Two principal kinds of folds are anticlines and synclines. Anticlines are archings of a series of strata, so that the strata dip away from the crest of the arch on both sides. Anticlines may be broad, with low angles of dip of the limbs, or sharp with steep dips of the limbs. All gradations are possible. Synclines are the opposite of anticlines, in that they form downward flexures or tough-like structures so that the strata dip toward the trough, on both sides. Anticlines and synclines commonly form in parallel succession, the side (limb) of an anticline becoming the side of the adjacent syncline. A succession of parallel folds developed in a thick series of stratified formations comprise the basic structure of mountain rangeslike the Appalachians. By prolonged erosion of such uplifted folds, the edges of the harder strata (especially sandstone) form ridges, whereas the valleys are developed in the softer, less durable rocks, commonly limestones. Thus the valley and ridge province of Western Maryland is a segment of the Appalachian folded mountain system, and the formations appear on geologic maps as relatively narrow, parallel belts in which the strata dip at moderate to high angles toward the northwest or the southeast.

FOLIATION (adjective, foliated): A layered structure possessed by crystalline' rocks of metamorphic origin in which the layers are composed of minerals of platy, tabular, or prismatic habit arranged in approximately parallel positions. Not to be confused with sedimentary lamination, stratification, or bedding which are due to original deposition of fragmental grains as in sandstones, shales and some limestones.
The foliations of metamorphic rocks imparts a rock cleavage, as in gneisses, schists, and slates.

FORMATION: A mappable rock unit. A formation may be composed of one or more rock types, such as sandstone, shale, schist, and others. Where the unit consists chiefly of one rock types, such as gneiss or sandstone it may be so designated, as Baltimore Gneiss, Tuscorarora sandstone, etc. Where the mapped unit consists of interbedded rocks of different types the term formation may be used, as Wissahickon formation, which includes interbedded sandstone and shale, etc. The formation is generally names (example, Waynesboro shale) for the locality in which it was first studies and identified, or where it is particularly well developed, but the name is commonly continued into remote areas where the same formation is present, as recognized by its distinctive features or fossils.

FOSSIL: The remains or imprint of an animal or plant of the geologic past, naturally preserved by burial within sedimentary beds.
The present day remains of organisms now in process of burial are not considered to be fossils.

FRACTURE CLEAVAGE: Fracture cleavage is the ability to part along closely spaced parallel surfaces of fracture or near fracture, commonly in a single set, but occasionally in intersecting sets. It differs from ordinary flow cleavage or schistosity in that the surfaces of breaking are not determined by a parallel arrangement of mineral particles, but are independent of such arrangement of mineral particles. Also, it does not pervade the entire mass and affect all particles, as does flow cleavage (Leith, 1923).

GARNET: A mineral of the garnet group, which includes several species consisting of silicates of iron, aluminum, magnesium, and calcium. Members of this group characteristically crystallize in equidimensional (isometric) grains, are harder than steel, and are most commonly red or brown; they are prominent constituents of some mica schists, especially muscovite schists, and more rarely of granite gneiss. The most common variety, almandite, is usually deep-red or brownish-red and weathers slowly to limonite.

GLAUCONITE: An amorphous (non-crystalline) granular secondary mineral, of green color, composed chiefly of iron, potassium, silica, and water. Occurs commonly as small grains and pellets in oceanic sediments formed near the shore; a prominent constituent of the so-called "greensands", used as a fertilizer. Common or prominent in some of the sedimentary formations of the Coastal Plain.

GNEISS: A foliated crystalline metamorphic rock in which the minerals are arranged in approximately parallel layers of feldspar, or feldspar and quartz, alternating with layers of mica and/or dark minerals (hornblende, and others). The layers or bands are thicker than those of schists. The foliation imparts a rock cleavage along which the rock tends to split and form thick slabs (cf., schist).

GNEISSIC OR GNEISSOSE: (adjective form) Having the foliated structure characteristic of gneiss.

GRANITE: granular , crystalline rock of tight, compact, granitoid texture composed chiefly of feldspar, quartz, and one or more accessory minerals (muscovite, biotite, hornblends, et. al.). Generally lacks foliation (cf., granite gneiss).
Commonly considered to be of igneous origin but also may have been derive
from some other rocks by chemical processes of replacement.
Although technically restricted to rocks of certain mineral composition, (as above) commercial granites include species of various mineral compositions (see ASTM standard definition, designation C119-50). The term is used here in its restricted technical sense.

GRANITIC: Having the general composition and texture of granite, that is, quartzose feldspathic rocks with granular interlocking crystalline texture.

GRANITOID: A texture characterized by interlocking crystalline grains of minerals recognizable by the unaided eye; phanerocrystalline, as opposed to dense texture; the characteristic texture of a granite, but possessed also by other crystalline rocks of similar origin.
Rocks of granitoid texture are tightly knit, having very low porosity (commonly less than 0.7%) and absorption (commonly less than 0.5%). Opposed to clastic (fragmental) texture.

GRANODIORITE: A petrographic term for a granitoid igneous rock of intermediate composition between granite and diorite, and thus partaking of the mineral composition of both.
In structure and composition may be broadly considered as granite, and is included in the ASTM definition of commercial granite.

GRAVEL: Unconsolidated materials composed predominantly of rounded or partly rounded rock fragments or pebbles more than 2mm (approximately 1/10 inch) in diameter (Wentworth system), usually in a matrix of sand. Gravels are further classified as very coarse, coarse, medium, fine, and vary fine, according to the average diameter of the predominant fragments; for purposes of these reports the approximate lower limits of these divisions are considered as very coarse, more than 10 inches; coarse (cobble gravel) 2.5 to 10 inches; fine, less than 1 inch. Such limits are, however, arbitrary, and practice varies as to size classification. These figures are given, therefore, only for general guidance.

GRAYWACKE: A variety of sandstone containing large amounts of clay and of rock fragments in addition to quartz and commonly feldspar. (Gilluly, Waters, and Woodford).
Graywacke is a poorly sorted sandstone. The rock fragments and feldspar grains are commonly angular or rather poorly rounded. The composition and texture indicate relatively rapid erosion and deposition without much chemical weathering. The clay content may be comparatively small except where the sediment was derived in part from argillaceous rocks such as shale. Graywackes are most commonly dark gray and rather variable in texture.

HORNBLENDE: A black or dark-green complex silicate mineral of the amphibole group; commonly composed of silica, calcium, magnesium, aluminum, and iron.
An accessory mineral in some granitic rocks and gneisses, and a prominent or dominant constituent of hornblende schists. Usually recognized by its color, prismatic form, cleavage planes at sharp angles, and hardness (greater than steel). In hornblende schists, the mineral commonly occurs as long, slender, or acicular crystals that lie in the planes of foliation.

IGNEOUS (adjective): Applied to rocks that have formed by the cooling and solidification of naturally molten rock material (magma). Examples: granite, diabase, lava, etc.

Igneous rocks comprise one of the three principal classes of rocks, the other two being Secimentary and Metamorphic. Igneous rocks are manifested as intrusive masses (batholith; stock; dike; sill; et al.), and extrusive (lavas).

INDURATED: Rendered hard, as by natural cementation and compaction; generally spoken of sediments that have become lithified.

INTRUSIVE: Intrusive rock; a mass of igneous rock that has been intruded into pre-existing rocks of any kind; see dike, sill, stock, batholith.

JOINT: A natural fracture in a rock formation, commonly vertical of nearly so, transverse to bedding or foliation planes, and along which there has been no appreciable relative displacement of the blocks (cf. *fault*). Joints may be closely or widely spaced and occur in two or more sets, commonly at approximately right angles. The blocks thus separated by joints vary in size and commonly are roughly rectangular,

LAVA: Molten rock material (see magma) that has been extruded upon the surface either from central vents (volcanoes) or deeply-extending fissures in the earth's crust. Such erupted materials form tabular sheet-like bodies--lava flows--commonly as a succession of such layers. Lavas vary considerally in both composition and texture; some are highly siliceous and glassy, others are dense (finely crystalline), and still others are porous owing to the escape of included gases during consolidation.

LIMESTONE: A rock formation of sedimentary origin, composed predominantly of the mineral calcite (calcium carbonate).
Some limestones are composed partly or largely of unaltered fragments of shells or other forms of calcite cemented together as a consolidated formation; such rocks are commonly porous and many have high porosity; others are dense and compact, with relatively low porosity.
Limestones in which the mineral dolomite (double carbonate of calcium and magnesium) is an appreciable, but subordinate, constituent are called *magnesium* or *dolomitic limestones* (see dolomite and dolostone).

LIMONITE: A hydrous oxide of iron derived by the oxidation of iron-bearing minerals. Characterized byits yellowish-brown to dark brown color; commonly earthy and porous, but may be dense and compact. The streak (color of the powder) is yellow to golden brown.
The common brown coloring matter of soils and weathered rocks; appears as stains on surfaces of outcrops. Occurs commonly also as nodular masses in residual clay derived from limestone and dolostone.

LITHOLOGY (adjective, lithologic): The science of rocks as related to kinds, varieties, and modes of origin. Essentially synonymous with petrology, the science of rocks which, however, includes the microscopic study of rocks (petrography).

LITHOSPHERE: That part of the Earth comprising the solid rock material. In contradistinction to the hydrosphere, which comprises the waters of the Earth, and to the atmosphere, which comprises the gaseous envelope.

MAGMA (adjective, magmatic): Primary molten rock material generally intruded into solid rocks of the lithosphere from deep sources; solidification of such intruded magma results in various forms of igneous rocks and of various compositions. Extruded upon the surface, as from volcanoes, magmas are called lavas.

MAGNETITE: A hard, black, oxide of iron, composition Fe_3O_4, occurring as small, magnetic grains in crystalline igneous and metamorphic rocks, especially the basic rocks (diorite, diabase, gabbro, peridotite), and gneiss; usually a minor accessory mineral. Weathers slowly to limonite. Identified readily by its magnetic property, black color, and hardness (scratches steel). Magnetite is an ore mineral or iron.

MANTLE: A term commonly applied to the general unconsolidated materials of recent origin overlying bedrock. See soil (engineering sense). It does not, however, include unconsolidated sedimentary formations of past geologic epochs or periods, such as the Cretaceous, Tertiary, and Quaternary formations of the Coastal Plain province. See regolith. Geologists now prefer the term regolith for such "mantle" materials, inasmuch as the term mantle is now technically applied to a deep zone of Earth directly underlying the Earth's crust.

MARBLE: A metamorphic rock composed predominantly of visible interlocking crystalline grains of calcite or dolomite; a completely recrystallized limestone or dolostone.
Varieties are sometimes indicated as calcite marble, dolomite marble, dolomitic marble. Variable in color.

METAMORPHIC (adjective): See Metamorphism.

METAMORPHISM: The process by which an igneous or sedimentary rock is completely recrystallized by being subjected to elevated temperature, pressure, and usually mineralizing solutions or gases. The resulting metamorphic rocks possess interlocking crystalline textures and are composed of relatively anhydrous minerals, most of which are similar to those of igneous rocks. The more common minerals of metamorphic rocks are quartz, feldspar, micas, hornblende, calcite, dolomite, serpentine, chlorite, and garnet, but many other species are commonly found in metamorphic rocks.
Metamorphic rocks (except marble, quartzite) commonly posses a foliated structure, and prominent rock cleavage, owing to the parallel orientation of the recrystallized grains of tabular, micaceous, or prismatic minerals. In the case of metzmorphosed sedimentary rocks, such foliation or cleavage generally transects the planes of original bedding which may, indeed, become completely obliterated. For this reason, the original structure and origin of the rock may be difficult to decipher, except by one trained or experienced in this branch of geology. The following are the most common varieties of metamorphic rocks:

METAMORPHIC ROCK	COMMONLY DERIVED FROM
Slate, Phyllite, Schist	Shale, siltstone, fine-grained igneous rocks
Gneiss	Granitoid igneous rocks (granite et al.); conglomerate, coarse arkose, or arkosic sandstone

Quartzite	Sandstone; Quartz-pebble conglomerate
Marble	Limestone; dolostone
Serpentine and Verd Antique	Some basic and ultrabasic igneous rocks

In Maryland metamorphic rocks in considerable variety and of complicated structure characterize the Piedmont belt, and directly underlie the nearly horizontal sediments and sedimentary rocks of the Coastal Plain belt.

MICA: A group name for certain rock-forming silicate minerals that possess a perfect cleavage so that they split readily into lustrous thin and flexible plates or flakes.
The two chief rock-forming varieties of mica are muscovite (white mica), and biotite, (black mica). Both are common constituents of granites, granitic gneisses, and mica schists.

MICACEOUS (adjective): Containing one or more minerals of the mica group in appreciable amount; also applied as a descriptive term to other minerals that can be easily split into thin sheets, as in the micas, such as chlorite.

MUSCOVITE: See under mica

OLIVINE: A silicate of iron and magnesium. Occurs as green or dark green grains in certain crystalline igneous rocks, chiefly of dark gray to nearly black color known as gabbro and peridotite. It alters readily to serpentine; upon weathering it forms limonite, so that such rocks are commonly weathered deeply to brown or dark brown, somewhat clayey soils; such rocks are commonly more deeply weathered than granites, schists, and gneisses.

ORTHOCLASE: (See under Feldspar).

PARTING: A small joint in coal or rock, or a layer or rock in a coal seam. Also applied to relatively thin shaly or sandy layers on bedding planes of thick-bedded sedimentary formations so that they constitute easy planes of breaking within such formations.

PEBBLE: A rounded or partly rounded rock fragment less than $2\frac{1}{2}$ inches in maximum dimension.

PHYLLITE: A fine-grained schistose metamorphic rock composed largely of minute flakes of muscovite (white mica), and possessing a pronounced foliation and rock cleavage.
Phyllites represent a stage between slate and mica schist in the progressive metamorphism of shales; and like slates they possess a perfect rock cleavage, but individual layers (foliae) are more prominently developed than in slate, and are apt to be crinkled, showing minute folds or wrinkles.

PHANEROCRYSTALLINE: An interlocking crystalline texture by which the component mineral grains are evident to the unaided eye; in contrast with dense or aphanitic texture. Most commonly applied to granitoid igneous rocks. (see also granitoid).

PLAGIOCLASE: (See under Feldspar).

PORPHRY: (adjective, porphyritic) An igneous rock in which relatively large crystals of one or more minerals are set in a finer grained ground mass, giving a spotted appearance.

PYROXENE: Name given to a group of minerals, of which augite is the most common mineral. See augite.

QUARTZ: A common vein and rock-forming mineral composed of silica (silicon dioxide, SiO_2).
Because of its abundance, its hardness, and its resistance, both chemically and mechanically, quartz,is one of the most common minerals. It is the principal component of sand, sandstone, and quartzite, an essential constituent of granitic rocks and most gneisses, and is a common constituent of mica schists.

QUARTZITE: A metamorphic rock composed of tightly cemented fragmental grains of quartz; a metamorphosed sandstone in which the original pores have been almost completely filled with added or recrystallized quartz. Quartzites are dense rocks with very low porosity and absorption, (commonly less than 1 percent). Quartzites are generally strong, resistant, and brittle, and are comparatively uniform in composition and texture.

REGOLITH: The uppermost zone of the lithosphere that comprises the general blanket of unconsolidated rock materials overlying bedrock. Includes all soils (engineering sense), whether formed in situ, by weathering etc., or by transportation and deposition of rock fragments. The "assemblage of loose material, consisting chiefly of rock particles that commonly mantles the bedrock at the Earth's surface". (longwell - Flint). See also soil.

RESIDUAL SOIL: Soil derived by weathering, and overlying the bedrock from which it was derived; soil not moved from its place of origin (Cf. transported soil, as alluviu, colluvium, et al).

RHYOLITE: A dense, fine-grained volcanic rock whose composition is generally equivalent to a granite, but whose grains are of microscopic size.
Some rhyolites have also a porphyritic texture (see porphyry), in which megascopic grains of one or more minerals, usually quartz or feldspar, are set in a dense groundmass.

SAND: UNconsolidated fine granular material composed chiefly of fragments of quartz, but with variable and subordinate amounts of other minerals, chiefly feldspar, with a size range between silt and gravel.
Sand is technically classified as fragmental grains within the size range of 1/16 mm to 1 mm (Wentworth System). As used in these reports the term is approximate and not based on actual measurements.

SANDSTONE: A sedimentary formation composed of naturally consolidated sand. Sandstone formations are commonly interlayered with other sedimentary formations, especially shale, siltstone, and conglomerate. They vary greatly in porosity, and hence in absorption. Their strength and weathering resistance are variable and depend in large measure on the degree to which the grains are cemented together, the kind of naturally cementing material, and the textural variability of successive layers; they are commonly weakened by thin interlayers of shale.

SCHIST: A crystalline metamorphic rock of thinly foliated structure due commonly to parallel orientation of micaceous, platy, elongated or prismatic crystals, so that the rock splits readily along closely spaced parallel planes, (Cf. gneiss; gneissic structure).

SCHISTOSE: Having the thinly foliated structure characteristic of schists.

SEDIMENTARY ROCK: A rock formed by the consolidation (lithification) of a sediment by compaction and natural cementation.
The common sediments and derived sedimentary rocks are:

SEDIMENT	DERIVED SEDIMENTARY ROCK
Gravel; cobbles; pebbles (rounded or partly rounded)	Conglomerate
Sand	Sandstone (see also arkose)
Silt	Siltstone
Mud, clay	Shale
Calcareous (calcium carbonate) including fragments of shells	Limestone, (Dolostone, if composed of the mineral dolomite. See under dolomite)
Angular fragments of rock	Sedimentary breccia (Cf. conglomerate, above)

Sedimentary rocks are stratified, that is, composed of successive more or less uniform and parallel beds representing consecutive deposition of layers of sediments, and tabular or lenticular in form.
The bedding lamination of sedimentary rocks is generally rendered obious on transecting surfaces because of slight variations in texture, porosity, or mineral composition of successive layers.
Bedding laminations should not be confused with the foliation and cleavage planes of certain metamorphic rocks, especially slate, phyllite, schists, and gneiss (see metamorphism).

SERPENTINE: A mineral composed of magnesia, silica, and water (a hydrous magnesium silicate). Commonly dense textured, moderately hard (scratched by steel), and of green color.
A common constituent of altered basic igneous rocks, and certain metamorphic rocks, especially verd antique marble. A fibrous variety is chrysotile (common asbestos).
Serpentine is used also as a rock name, denoting a rock mass made up mostly of the variety of the mineral known as antigorite, which is a massive and dense aggregate of microscopic plates of serpentine.

SHALE: A stratified fragmental sedimentary rock composed of compacted and integrated detrital minerals of clay sizes, and composed chiefly of clay minerals. Compacted and lithified muds and clays, thinly laminated, soft, and fissile along bedding planes; ordinarily breaks into small flakes or chips.

SILICATE: A chemical compound of silica with base or alkali elements.

SILICEOUS: Having a relatively high content of silica (SiO_2), either as the mineral quartz or in combination as silicate minerals. Commonly applied to rocks containing excess silica as the mineral quartz or related varieties (chert, flint, et al.).

SILL: A tabular or sheet-like mass of igneous rock intruded between, and parallel to, enclosing sedimentary strata. (Cf. dike)

SILT: An unconsolidated clastic sediment, most of the particles of which are between the clay and fine sand sizes.
The size range for silt differs slightly in various technical classifications; the American Geological Institute (AGI) definition gives the range from 0.053 to 0.002 mm in diameter. In the Wentworth system (adopted by many) the size range for silt is 1/256 to 1/16 mm. As used in these reports the term is only approximate and not based on actual measurements.
Most silt in Maryland is either of alluvial origin, occurring as thin layers within a sequence of flood plain sediments along major valleys, or of marine origin, occurring as thicker beds within the coastal plain sequence of sedimentary formations.
Silt is commonly composed principally of minute quartz and feldspar grains, subordinately of clay minerals.

SILTSTONE: A consolidated silt; commonly interlayered with beds of sandstone and shale.

SLATE: A fine-grained metamorphic rock possessing a well developed cleavage whereby the rocks split readily into thin smooth sheets.

SOIL: In the engineering sense, soil is the entire blanket of unconsolidated rock debris that rests upon bedrock. In places it may be several hundred fee thick, though commonly much thinner.
Engineering soil should not be confused with soil in the agricultural usage, which comprises only the thin, top portion that is capable of supporting vegetation, and which is derived from the top of the engineering soil blanket by the action of organic acids and weathering, with the development of humus to form the various kinds of loam.
Below the zone of agricultural soil, which is rarely more than two to three feet thick, and is commonly less, the physical properties of the unconsolidated material may be markedly different.

STOCK: A knob-like discordant intrusive body of granitoid igneous rock.
A stock is similar in general shape and mode of occurrence to a batholith but is smaller. Technically it may be described as being roughly circular or lenticular in ground plan, and with an exposed area of less than 40 square miles, whereas a batholith has an exposed area of 40 square miles or more. Actually there is no difference, except in size, between a stock and a batholith, and most stocks are probably knobs or projections of batholiths.

STRATIFICATION: The arrangement of sedimentary rocks in beds or layers. The planes separating layers of differing composition or texture are called stratification planes.

STRATUM (plural, Strata; adjective, Stratified): A unit layer or bed of sedimentary rock.

STRIKE: The trend direction of the line of intersection of a geologic plane, (as a bedding plane, fault plane, or joint) with a horizontal plane. The strike is expressed in compass terms, as North 35 degrees east (N35°E), North 27 degrees west (N27°W), N-S, E-W, etc. (see attitude).

SURFICIAL: Relates to formations or processes occurring on the surface.

SURFICIAL GEOLOGY: Pertaining to materials exposed at the surface whether consolidated or unconsolidated. A surficial geologic map indicates the distribution of recent surficial materials, such as sand, gravel, clay, glacial till, et al., as well as actual exposures of bedrock. In contradistinction, bedrock maps indicate the distribution of consolidated formations of all ages, the distribution being interpreted from exposures as though all soil materials were removed.

SYNCLINE: See Folds.

TALC: A flaky mineral; white, gray or apple-green in color; very soft; pearly or greasy luster; greasy feel; composition hydrous magnesium silicate. Also called steatite; soapstone. Talc schists are metamorphic rocks composed chiefly of the mineral talc.

TALUS: A deposit of rock fragments, accumulated by gravity, at the base and on the lower slope of a rock cliff or bluff. "A heap of rock waste sloping outward from the cliff that supplies it." (Longwell-Flint) The material of talus consists chiefly of angular fragments of rock, loosened by weathering and frost action and accumulated by gravity and solifluction. Talus deposits are commonly very thick at the bases of high cliffs and may offer considerable difficulty in excavation because of comparative instability.

TONALITE: A granitoid igneous rock; a variety of quartz-diorite closely allied in composition and texture to granite and granodiorite. Included in ASTM definition of commercial granite, and for engineering purposes may be considered to be granite.

TRAP: A broad field term applied to dense or fine-grained dark gray, black or greenish black igneous rocks, either intrusive or extrusive. It includes chiefly the petrologic species basalt, and diabase; it is sometimes broadened in the quarrying industry to include the coarser grained dark igneous rocks, (diorite, gabbro, peridotite, etc.) but this applicatio departs widely from its original use and in this broadened sense the term is not acceptable to geologists.

The true trap rocks (as defined above) are particularly valued for crushed stone and aggregate because of their density, hardness, and natural binding power.

TUFF: A fine-grained clastic rock of volcanic origin; a rock consisting of lithified volcanic ash and dust.

ULTRABASIC: A term applied to certain igneous rocks to indicate relatively very high contents of the base elements, iron and magnesia, and correspondingly low contents of silica. Example, peridotite. Ultrabasic rocks never contain free quartz, and the silicate minerals are those of relatively low content of combined silica.

VEIN: A thin tabular or lenticular body formed by filling of pre-existing cracks or fissures in bedrock by one or more minerals, such as quartz veins, calcite veins, et al.

VERD ANTIQUE: A metamorphic rock composed chiefly of serpentine and capable of taking a high polish (Commercial Verd Antique Marble). Commonly brecciated and healed by deposition of white, gray, or brown carbonate minerals (calcite; dolomite) in the fractures, hence the veined appearance. Some verd antiques also contain veins of asbestiform minerals, but such are generally inferior as a commercial stones. Some verd antiques and serpentine rocks serve adequately as crushed stone for road "metal", but are generally unsuitable for aggregate because of the relative instability of the mineral constituents, which easily yield water under decomposition.

VESICULAR: As applied to lavas, indicating a spongy or very porous fabric due to obvious pores, cavities, vesicles, etc., and brought about by escape of contained gases during consolidation of the lava.

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Aquifers

II AQUIFERS

A. Introduction

As a result of the close physical relationship between geology, aquifer formations and mineral outcrops we have chosen to make use of the same base map series for all three variables. Specifically, we are refering to the Engineering Geology Maps produced by the University of Maryland's Department of Civil Engineering in 1965 and modified by the Department of State Planning and the Maryland Geologic Survey for the Maryland Generalized Land Use Plan. This map series utilized the General Highway Maps of the State Highway Administration as its base sheets.

In subsequent sections the same 4 digit coding system explained in detial in the Geology section of this manual is used to interpret data. In addition, a map series which originally appeared in Ground Water Aquifers and Mineral Commodities of Maryland Published by the Department of State Planning in May of 1969 is included.

1. Aquifers

An aquifer is a permeable underground geological formation through which ground water flows; a recharge area is a place where water enters an aquifer. Although ground water is of secondary importance for most large urban areas in Maryland, in rural areas it is the only available source of potable water. Due to the danger of contamination from septic tanks, land fills, and factory wastes, all future development should be controlled to protect Maryland's aquifers and their recharge areas. The use of septic tanks or other on-site sewage disposal systems should not be allowed in known recharge areas where soil is not deep enough to allow septic effluent to percolate completely.

The covering of recharge areas with parking lots and buildings greatly decreases the amount of new water entering the aquifer. To compensate for this type of coverage and maintain the ground water supply, a river or stream crossing the recharge area could be damed with the resulting reservoir providing the necessary water input.

Overdrawing is another problem to be considered. When too much water is taken out of an aquifer at one location, at another well some distance away the quality and/or quantity of water will decrease. Salt water from the Bay or Ocean may invade an aquifer if too much fresh water is withdrawn.

In any event, its clear that an aquifer recharge area is not capable of sustaining heavy development and still provide quality water for its users. A good land use plan should direct away or at least limit the type and density of development in recharge areas. Hence the Maryland Generalized Land Use Plan is including a discussion of aquifers in its land capability analysis in order to direct development in a way that allows for the optimum preservation and use of Maryland's ground water resources.

2. Ground Water

Ground water is the rain that has seeped through the soil and has become stored in the geologic formation below. The amount of water that can be stored in particular type of material depends upon its porosity. The porosity is the percentage of the rock that is open between particles. The rate at which a rock will transmit water depends on its permeability. Permeability is a measure of the size, rather than number of openings in a rock. Thus, sandstone which has large spaces between particles, is very permeable while shale and clay, which have very small openings, do not transmit water well. This characteristic of clays and shales allows them to act as barriers to water movement, and when a sandstone is sandwiched between these impermeable layers they act like a pipeline by holding the water in the sandstone. Maryland's diverse geology causes several different ground-water situations, each of which must be looked at independently.

The layered unconsolidated formation of sand and clay that constitutes the Coastal Plain provides the structure for Maryland's aquifer systems east of the Fall line. It outcrops in successively younger belts away from the Fall Line in a southeasterly direction. The dip (generally less than 1°) of the formations is in the same direction, drawing water collected in the outcrop across and beneath the Coastal Plain. The quality of the water varies greatly depending upon the composition of the formation it is stored in. Problems may result from excessive amounts of dissolved minerals, particularly iron, calcium, and magnesium.

In the crystalline rocks of the Piedmont Plateau and Blue Ridge Mountains, ground water is stored and transmitted through joints and fractures developed in the rock. The amount of water available to a well varies with the size and number of the cracks; therefore, yields are quite variable.

In folded shales and sandstones of the Appalachian province, water is contained under both water-table and artesian conditions. The principle recharge areas are the crests and slopes of ridges. Many of the sandstones are porous and yield well, but the fracturing the denser quartzites and shales can yield enough water for domestic use.

B. Major Aquifers in Maryland

The following discussion of major aquifers in Maryland originally appeared in Ground water Aquifers and Mineral Commodities in Maryland published by its Department of State Planning in 1969 with the assistance of the Maryland Geological Survey and the U.S. Geological Survey. The Piedmont and Appalachian Regions are treated differently from the Coastal Plain because of their geological complexity. They are described in terms of three hydrologic units which depend upon their productive capacities rather than their depth of occurrence. On the other hand, depth of occurence is the only feature which is mapped on the Coast Plain aquifer maps.

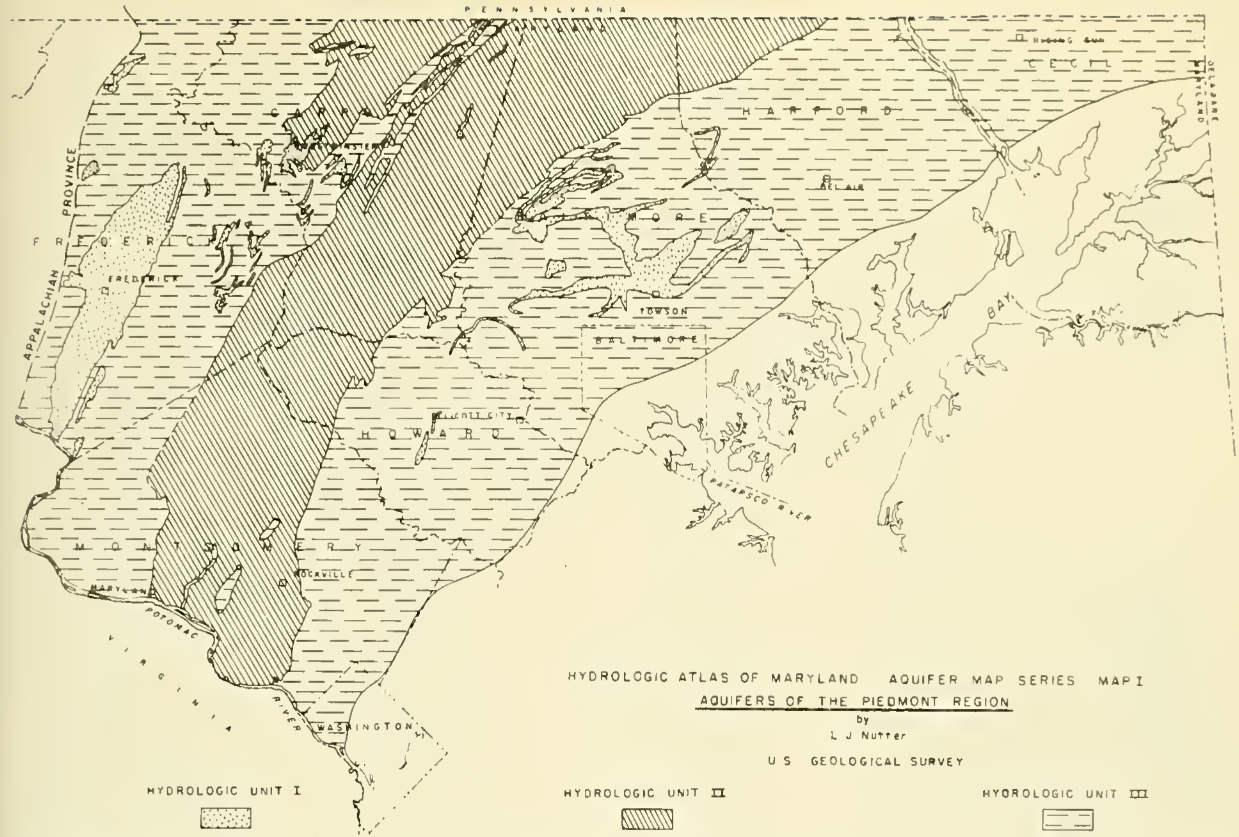
The geologic formations constitution Hydrolic Unit I in the Piedmont and Appalachian regions have approximately a 20 percent change of yielding 50 gpm (gallons per minute) or more; on the other hand, this probability is reduced to 6 percent and 2 percent in Units II and III respectively. These are, of course, statistical inferences and provide only a very generalized representation of the water-yielding characteristics of the rocks. Local geologic anomalies can substantiallyalter these relationships.

The following maps (Figures 4-13) are included only for illustrative purposes. Those aquifer maps which were developed from the Engineering Geology maps are summarized by the conversion tables which appear in a subsequent section of this manual.

1. Piedmont and Appalachian Regions

The statistical data presented in Aquifer Map Series I and II which follow (Figures 4 and 5) were originally compiled for the Piedmont and Appalachian regions combined. However, the data were presented on two maps to allow for a more convenient-sized illustration. The legends on the two maps are identical except that the geologic units (formations) within each region are included only on the map of that region.

It should be emphasized that within any one of the three hydrologic units defined on Aquifer Map Series I and II, extreme variability in yields of individual wells exists. This variability results in part from the fact that the topographic position of well sites and the geologic structure which causes jointing and fracturing in the rocks also determines the amount of water an individual well will yield. The evaluation of specific water supply problems must consider these factors as well as the geologic formation outcropping at a given locality.



HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP I

AQUIFERS OF THE PIEDMONT REGION

by

L J Nutter

U S GEOLOGICAL SURVEY

HYDROLOGIC UNIT I ░	HYDROLOGIC UNIT II ▨	HYOROLOGIC UNIT III ☰
Limestones of the Frederick Valley including Grove Ls and Frederick Ls Marbles of the Piedmont including Wakefield Marble and Cockeysville Marble	Schists and quartzites of the central Piedmont including. Marburg Schist and Wissahickon Fm (Micaceous qtzte member and Upper pelitic schist member)	Shales, sandstones, and conglomerates of the Triassic lowland including: Gettysburg Sh and New Oxford Fm Phyllites, schists, and metavolcanic rocks of the western Piedmont including metabasalt and metarhyolite, Ijamsville Fm, and Urbana Phyllite Schists, gneisses, and intrusive rocks of the eastern Piedmont including granite, granodiorite, gabbro, and metagabbro, Wissahickon Fm (Boulder gneiss member and Lower pelitic schist member), Setters Fm, and Baltimore Gneiss
Hydrologic Unit I contains the most productive aquifers within the areas of this map It includes those formations in which the average well yields and specific capacities fall in the upper 25 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells range from less than 1 to about 580 gallons per minute (gpm) In this unit there is approximately a 20 percent chance of getting a well yielding 50 gpm or more, that is, 1 well out of 5 may be expected to yield 50 gpm or more The rocks in this unit are mainly carbonates subject to processes of solutional weathering and having a fair degree of permeability	Hydrologic Unit II contains those aquifers of intermediate productivity, and includes those geologic units in which the average well yields and specific capacities fall between 25 and 50 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells in this unit range from less than 1 gpm to about 320 gpm. In this unit there is about a 6 percent chance of getting 50 gpm or more that is, only 1 well in approximately 17 may be expected to yield 50 gpm or more This unit includes several different types of rocks but is intermediate in hydrologic properties as indicated by the yields of wells and their specific capacities	Hydrologic Unit III contains the poorest aquifers within the mapped area It includes those geologic units in which the average yields and specific capacities of wells fall in the lower 50 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells in this unit range from less than 1 to 200 gpm In this unit there is only a 2 percent chance of getting 50 gpm or more, that is, only 1 out of 50 wells may be expected to yield 50 gpm or more This unit includes schists, phyllites, gneisses, and gabbro Some sandstones and shales of relatively low average permeability are also included.

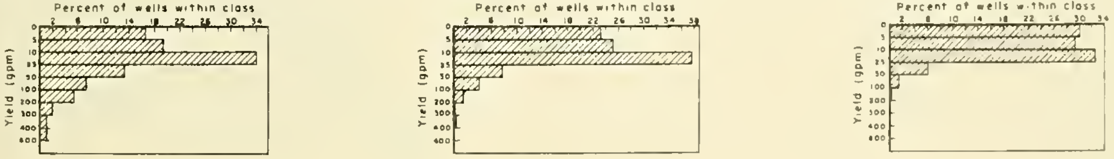


FIGURE 4

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY

EXPLANATION

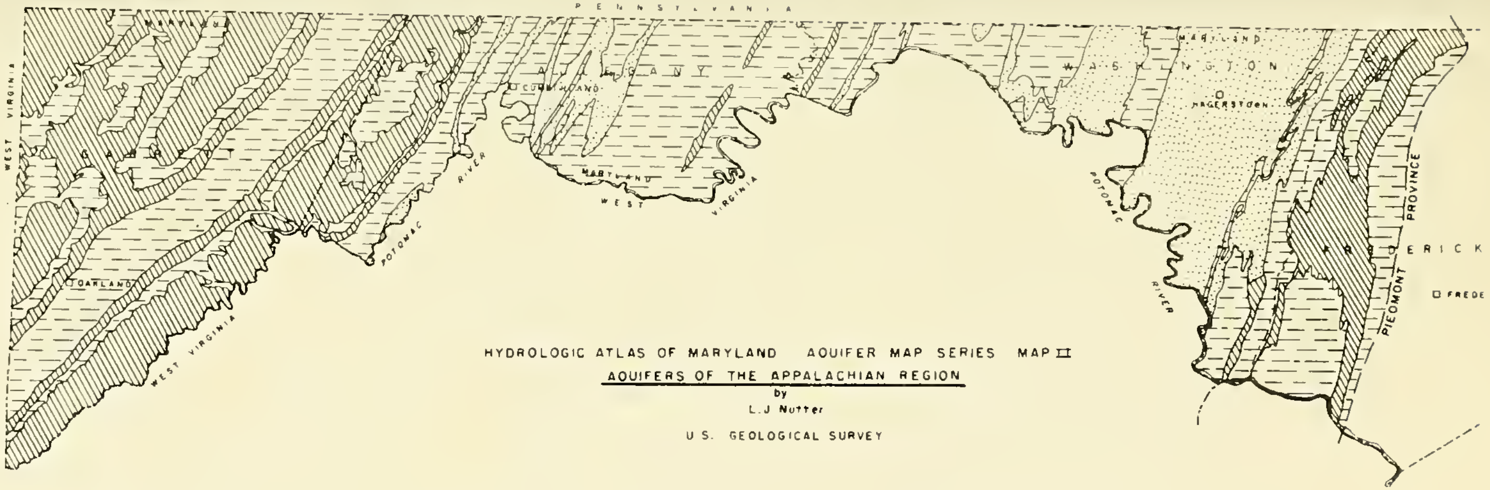
The aquifers of this area are shown on this map as three hydrologic units Each different geologic unit has been placed into one of three hydrologic units, based upon reported specific capacities[1] and yields of wells.

Publications of the Maryland Geological Survey have been the primary source of data for the map, which provides only a very generalized representation of the water-yielding character of the rocks, and should be used accordingly

[1] Specific capacity is the yield per foot of drawdown of the water level (gpm/ft)

THE PREPARATION OF THIS MAP WAS FINANCIALLY AIDED THROUGH A FEDERAL GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE URBAN PLANNING ASSISTANCE PROGRAM AUTHORIZED BY SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED

THE PREPARATION OF THIS MAP WAS FINANCIALLY AIDED THROUGH A FEDERAL GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE URBAN PLANNING ASSISTANCE PROGRAM AUTHORIZED BY SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED



HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP II

AQUIFERS OF THE APPALACHIAN REGION

by

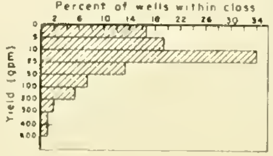
L.J Nutter

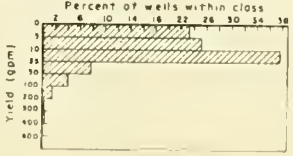
U.S. GEOLOGICAL SURVEY

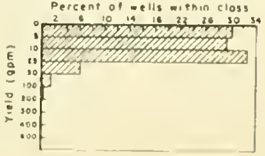
FIGURE 5

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY

HYDROLOGIC UNIT I ▒	HYDROLOGIC UNIT II ▨	HYDROLOGIC UNIT III ▤
Limestones and dolomites of the Hagerstown Valley including Beekmantown Group, Conococheague Ls, Elbrook Ls, and Tomstown Dol Sandstones and limestones of the Valley and Ridge including Oriskany Ss, Helderberg Ls, and Tonoloway Ls	Sandstones, shales, and shaley limestones of the Valley and Ridge and Appalachian Plateau including Conemaugh Fm, Mauch Chunk Fm, Greenbrier Ls and Pocono Fm Catoctin Metabasalt of the Blue Ridge	Sandstones and shales of the Valley and Ridge and Appalachian Plateau including Monongahela Fm, Allegheny and Pottsville Fms, Hampshire Fm, Jennings Fm, Romney Sh, Wills Creek Sh, Clinton Group, and Martinsburg Sh Rocks of varied lithologies in the Hagerstown Valley including Chambersburg Ls and Waynesboro Fm Rocks of varied lithologies in the Blue Ridge including Antietam Quartzite, Harpers Fm, Weverton Fm, Loudoun Fm, metarhyolite, and granite gneiss
Hydrologic Unit I contains the most productive aquifers within the areas of this map It includes those formations in which the average well yields and specific capacities fall in the upper 25 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells range from less than 1 to about 580 gallons per minute (gpm) In this unit there is approximately a 20 percent chance of getting a well yielding 50 gpm or more, that is, 1 well out of 5 may be expected to yield 50 gpm or more The rocks in this unit are mainly carbonates subject to processes of solutional weathering and having a fair degree of permeability	Hydrologic Unit II contains those aquifers of intermediate productivity, and includes those geologic units in which the average well yields and specific capacities fall between 25 and 50 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells in this unit range from less than 1 gpm to about 320 gpm In this unit there is about a 6 percent chance of getting 50 gpm or more, that is, only 1 well in approximately 17 may be expected to yield 50 gpm or more. This unit includes widely differing types of rocks but is intermediate in hydrologic properties as indicated by the yields of wells and their specific capacities	Hydrologic Unit III contains the poorest aquifers within the mapped area It includes those geologic units in which the average yields and specific capacities of wells fall in the lower 50 percent of a list of formations ranked according to their water-yielding characteristics The yields of wells in this unit range from less than 1 to 200 gpm In this unit there is only a 2 percent chance of getting 50 gpm or more, that is, only 1 out of 50 wells may be expected to yield 50 gpm or more. This unit includes widely differing types of rock which generally have low permeability







EXPLANATION

The aquifers of this area are shown on this map as three hydrologic units Each different geologic unit has been placed into one of three hydrologic units, based upon reported specific capacities 1/ and yields of wells

Publications of the Maryland Geological Survey have been the primary source of data for the map, which provides only a very generalized representation of the water-yielding character of the rocks, and should be used accordingly

1/ Specific capacity is the yield per foot of drawdown of the water level (gpm/ft)

2. Coastal Plain Region

PATUXENT FORMATION

Sands in the Patuxent Formation (Figure 6) constitute an important source of ground water along the part of the Coastal Plain immediately southeast of the Fall Zone. The Patuxent Formation consists of irregularly stratified layers of sand, gravel, clay, and mixtures thereof. The formation ranges in thickness from a few feet in its outcrop area to as much as 2,300 feet near Ocean City. In Harford, Baltimore, Anne Arundel, and Prince George's counties, where it is most productive, the maximum thickness of the aquifer is seldom more than 350 feet. In the Baltimore area about 50 percent of the total formation is reported to be water-bearing sand and gravel, but the proportion of this sand and gravel decreases to the southwest toward Washington, D.C. Yields of wells in the most favorable localities range from a few hundred to as much as 1,200 gallons per minute (gpm).

The Patuxent Formation is a source of groundwater for the towns of Aberdenn, Bowie, Glen Burnie, and some of the suburban communities southeast of Washington, D.C. It furnishes important supplies of cooling water to several industries in and near Baltimore City. The water is commonly soft and of low mineral concentration, but locally it may require treatment for iron removal and/or reduction of acidity.

In many areas of the State, the Patuxent Formation is untapped and may constitute a potential source of large supplies of potable ground water.

HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP III

AQUIFERS OF THE COASTAL PLAIN - PATUXENT FORMATION

by

L. J. NUTTER AND E. G. OTTON

U S GEOLOGICAL SURVEY

FIGURE 6

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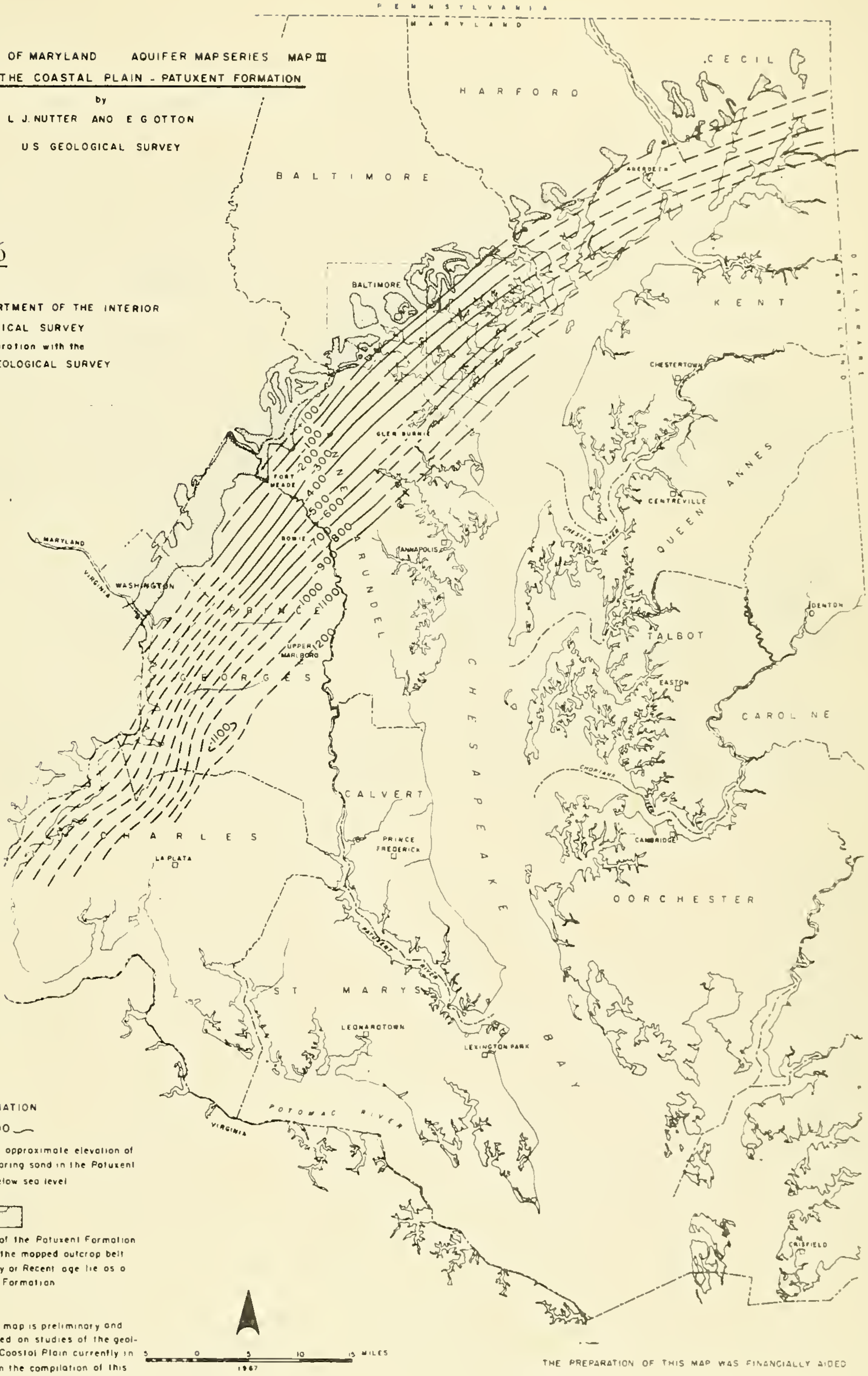
in cooperation with the
MARYLAND GEOLOGICAL SURVEY



EXPLANATION

-200

Structure contour showing the approximate elevation of the top of the major water-bearing sand in the Patuxent Formation, in feet, above or below sea level

Approximate outcrop pattern of the Patuxent Formation In some locations adjacent to the mapped outcrop belt younger deposits of Quaternary or Recent age lie as a thin veneer over the Patuxent Formation

Note Information on this map is preliminary and is subject to revision, based on studies of the geology and hydrology of the Coastal Plain currently in progress The data used in the compilation of this map are primarily from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

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PATAPSCO AND RARITAN FORMATIONS

Water-bearing sands in the undifferentiated Patapsco and Raritan Formations (Figure 7) comprise the most widely used aquifers in the Maryland Coastal Plain. These formations consist of irregularly stratified layers of variegated gravel, sand, silt, and clay in varying proportions. Sandy sediments are most common in the Patapsco Formation and clayey sediments tend to predominate in the Raritan Formation. The thickness of the combined unite ranges from a few feet in the outcrop area to more than 500 feet near Claiborne. The thickness probably increases to more than 1,000 feet at Salisbury. At sparrows Point, where the formations are approximately 300 feet thick, about one-third of the strata consist of water bearing sand and gravel. The proportion of sand decreases toward the southwest near the Washington, D.C. area. Yields of wells range from less than 100 to 2,160 gallons per minute (gpm) although wells yielding more than 1,000 gpm are considered exceptional. The most productive well is in the Bowie area in Prince George's County.

The Patapsco and Raritan Formations are a source of groundwater for the towns of Annapolis, Glen Burnie, Odenton, Forest Heights, Indian Head, and Bowie. Many industries in the Baltimore area use cooling water obtained from these aquifers. The chemical quality of the water is generally good, but locally treatment for iron removal and de-acidification is required.

Large additional ground-water supplies are available for development from the Patapsco and Raritan Formations. In the northern counties of the Eastern Shore the cost of treating the water may be a factor limiting the use of the aquifers.

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FIGURE 7

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GEOLOGICAL SURVEY
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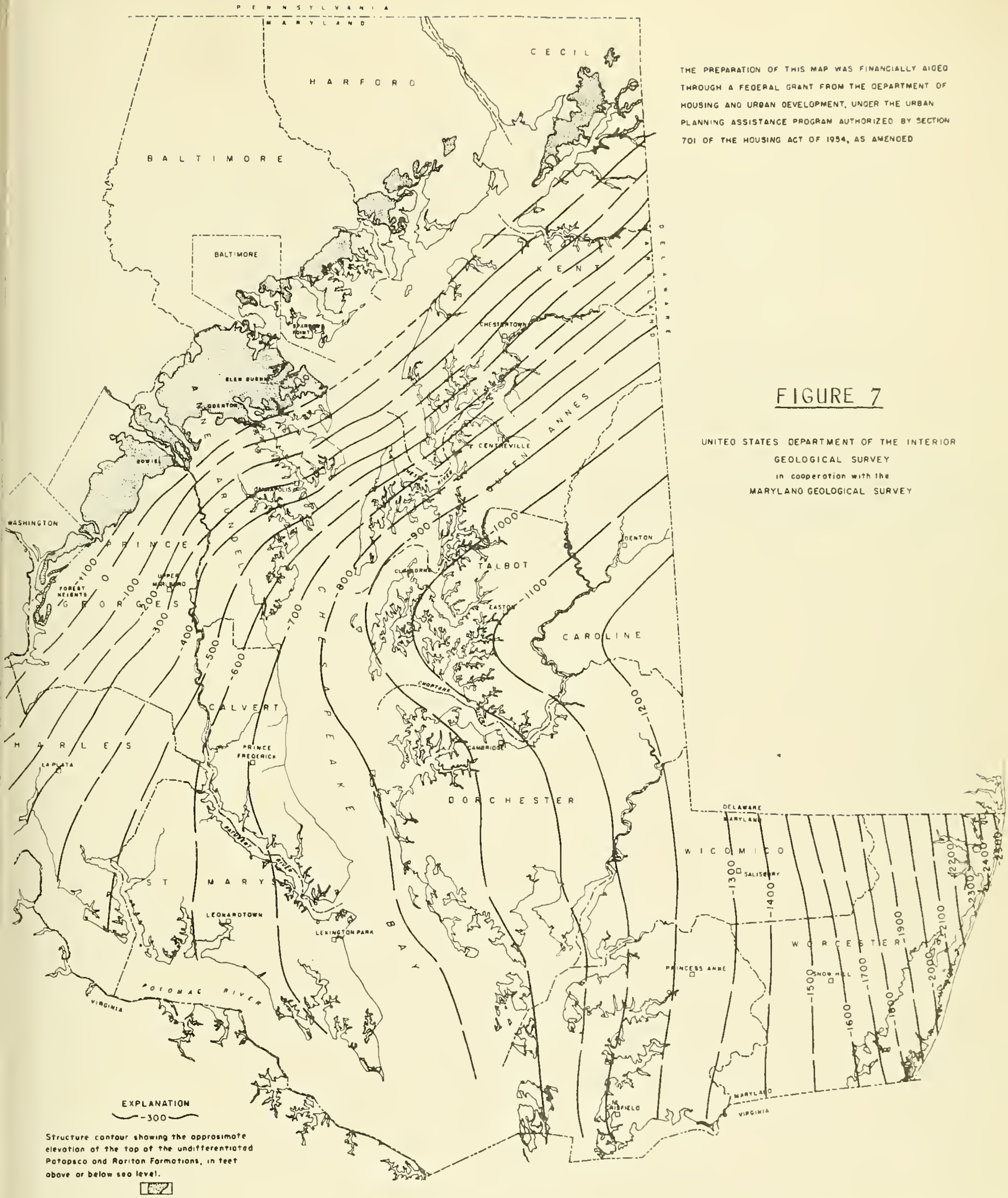

EXPLANATION

—-300—

Structure contour showing the approximate elevation of the top of the undifferentiated Patapsco and Raritan Formations, in feet above or below sea level.

▨

Approximate outcrop pattern of the Patapsco and Raritan Formations. In many locations within the mapped outcrop belt, younger deposits of Quaternary or Recent age lie as a veneer over the mapped unit.

Note: Information on this map is preliminary and is subject to revision, based on studies of the geology and hydrology of the Coastal Plain currently in progress. The data used in the compilation of this map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey.

HYDROLOGIC ATLAS OF MARYLAND   AQUIFER MAP SERIES   MAP IV

AQUIFERS OF THE COASTAL PLAIN – PATAPSCO AND RARITAN FORMATIONS

by

H J HANSEN
MARYLAND GEOLOGICAL SURVEY

E G OTTON
U S GEOLOGICAL SURVEY

MAGOTHY FORMATION

The Magothy Formation (Figure 8) is one of the most extensive water-bearing formations (containing aquifers) in the Coastal Plain of Maryland. The Magothy consists chiefly of beds of sand and gravel with interbedded layers of clay and silty clay. The sands commonly contain fossil wood and, in places, marine shells. The formation ranges from a few feet thick near La Plata to as much as 160 feet thick northeast of Upper Marlboro.

The Magothy supplies water to wells at or near several towns in the State; among these are Upper Marlboro, Waldorf, Easton, Cambridge, and Crisfield. Yields of wells range from a few to several hundreds of gallans a minute. The water is commonly usable for most purposes but locally, as in the Annapolis area, may be acidic and high in iron content.

The aquifer is believed capable of sustaining substantial additional development in many areas where it has been tapped by only a few wells or where adequate water supplies have heretofore been obtained from other shallower aquifers.

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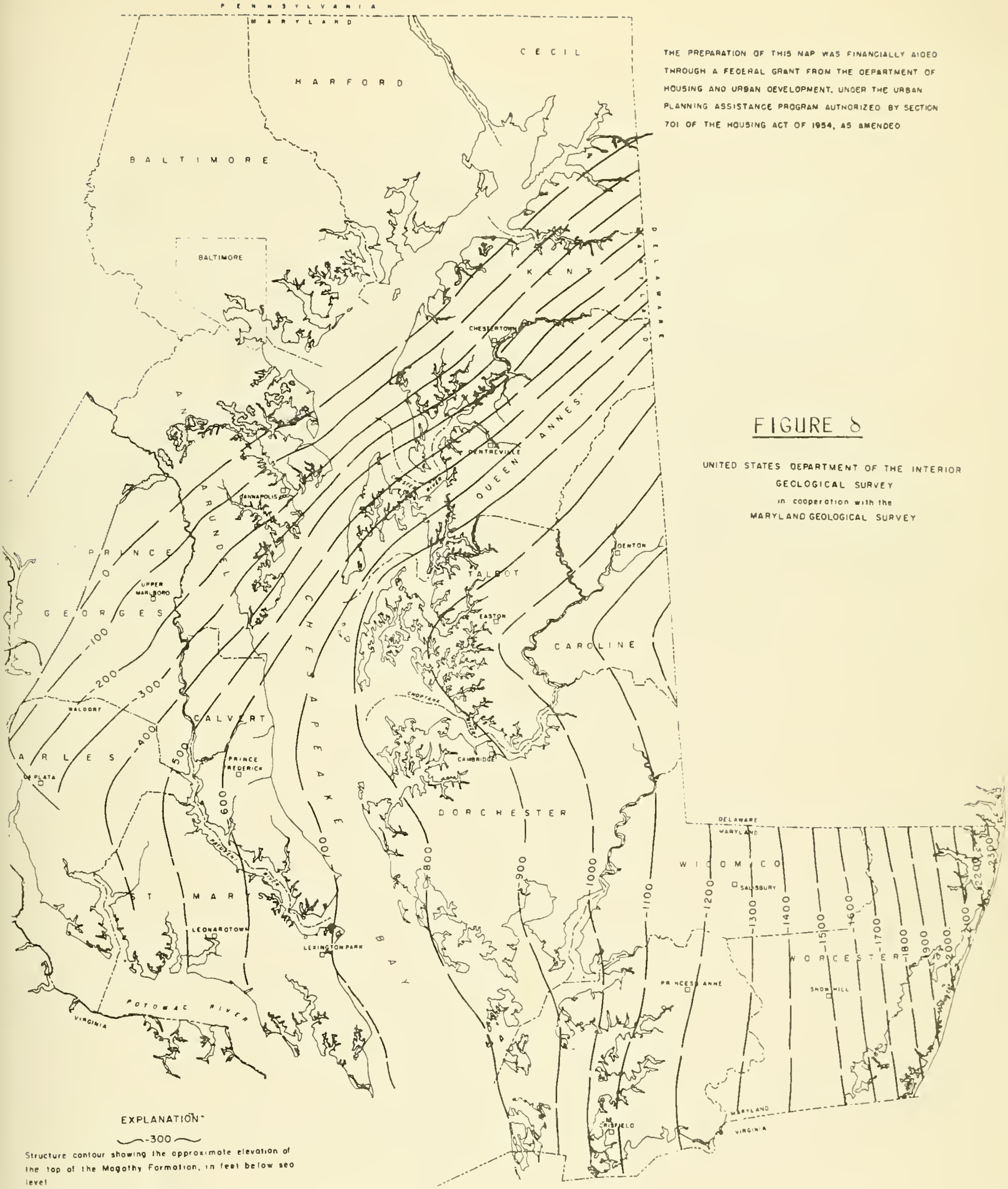


FIGURE 8

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY

EXPLANATION

-300

Structure contour showing the approximate elevation of the top of the Magothy Formation, in feet below sea level

Approximate outcrop pattern of the Magothy Formation In places in Cecil and Kent Counties the outcrop is covered by younger deposits of Pleistocene and Recent age

Note Information shown on this map is preliminary and is subject to revision based on studies of the geology and hydrology of the Coastal Plain currently in progress The data used in compilation of this map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP V

AQUIFERS OF THE COASTAL PLAIN - MAGOTHY FORMATION

by

H J HANSEN
MARYLAND GEOLOGICAL SURVEY

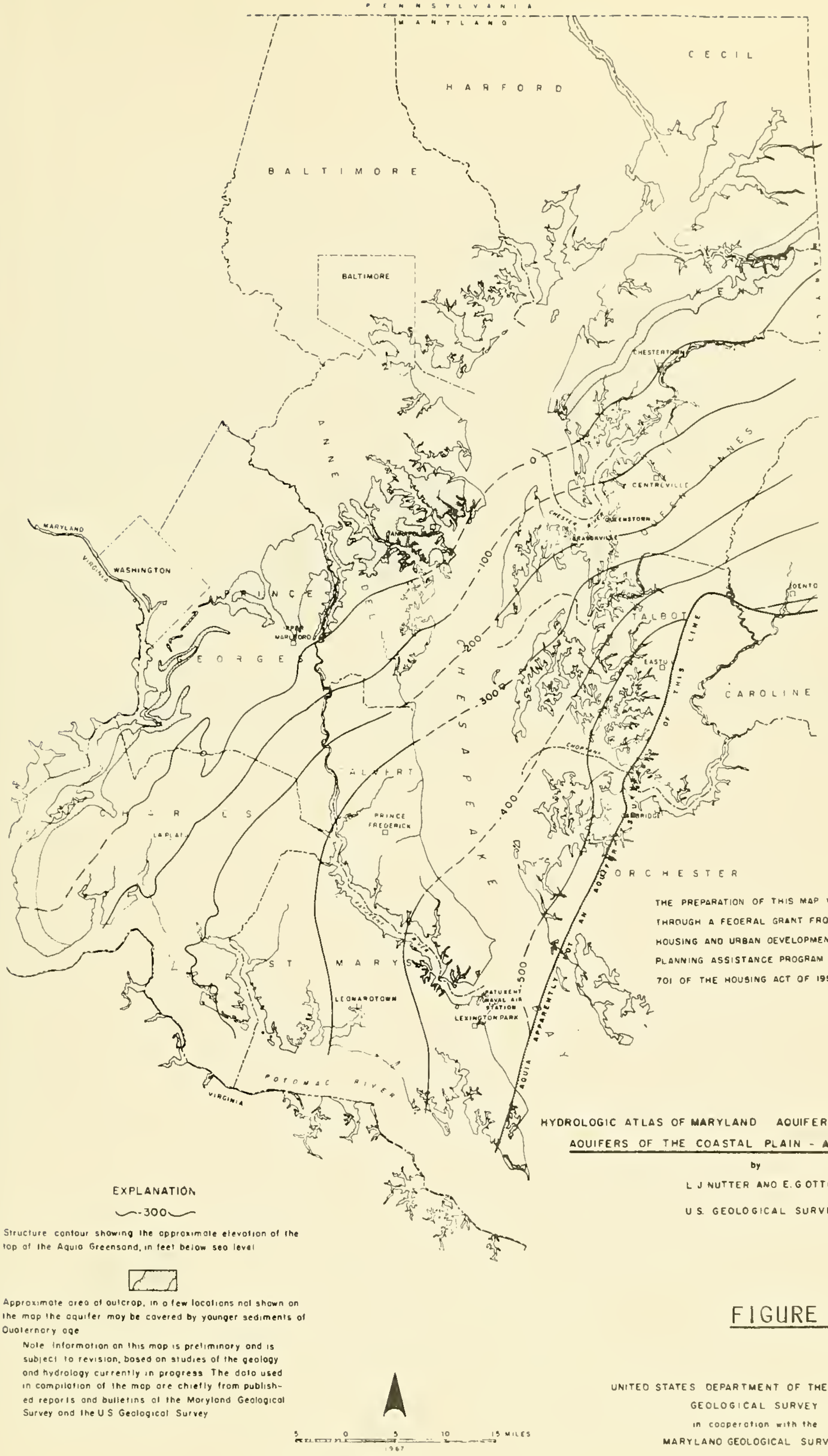
E G OTTON
U S GEOLOGICAL SURVEY

AQUIA GREENSAND

The Aquia Greensand (Figure 9) is one of the most important aquifers in the five Southern Maryland counties and in Kent, Queen Anne's, Caroline, Talbot, and Dorchester counties on the Eastern Shore. The Aquia consists of moderately glauconitic quartz sand with a few clay layers and some indurated layersin its middle and basal parts. Its thickness ranges from a few feet along the outcrop belt to as much as 231 feet in Talbot County. Wells producing from the Aquia Greensand have yields ranging from a few to 1,300 gallons per minute (gpm). The most productive well ia used for irrigation and is located in eastern Kent County. A well yielding 350 gpm was tested at the Patuxent Naval Air Station in St. Mary's County where the formation is a primary ground-water source.

The following towns use the Aquia as the major source for their municipal water supply: Chestertown, Centreville, Grasonville, Queenstown, and Leonardtown. During recent years the aquifer has become an important source of water for supplemental irrigation on the Eastern Shore. The water is generally of good chemical quality and in many localities is usable with little or no treatment. However, locally treatment for iron removal may be required.

The Aquia Greensand is capable of additional development in many localities in the Coastal Plain.



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HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP VI

AQUIFERS OF THE COASTAL PLAIN - AQUIA GREENSAND

by

L J NUTTER AND E. G OTTON

U.S. GEOLOGICAL SURVEY

EXPLANATION

-300

Structure contour showing the approximate elevation of the top of the Aquia Greensand, in feet below sea level

▨

Approximate area of outcrop, in a few locations not shown on the map the aquifer may be covered by younger sediments of Quaternary age

Note Information on this map is preliminary and is subject to revision, based on studies of the geology and hydrology currently in progress. The data used in compilation of the map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U.S. Geological Survey

FIGURE 9

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY

PINEY POINT FORMATION

The Piney Point Formation (Figure 10) is a major aquifer in Calvert, St. Mary's, Dorchester, Talbot, and Caroline counties, and extends southward into Virginia and northeastward into Delaware. The formation consists of glauconitic medium-to coarse-grained sand and interspersed shall beds from 10 to more than 100 feet thick, but generally only 50 to 60 feet thick. The Piney Point Formation has no known surface outcrop. The maximum altitude of its known occurrence is about 80 feet below sea level at a point along the lower Patuxent River. Locally the sands of the Piney Point Formation appear to be hydrologically connected with the sands of the underlying Nanjemoy Formation, and therefore, the two formations may function as a single aquifer. The yields of wells range from less than 10 to about 1,200 gallons per minute (gpm). The most productive well is a part of the public supply system of Cambridge, Maryland.

The Piney Point Formation is a source of water for the Patuxent Naval Air Station. It is also tapped by hundreds of domestic wells throughout the area. The chemical quality of the water is good and is relatively uniform. Water treatment is seldom required.

The apparently limited extent of this formation coupled with the limited recharge capability of the aquifer suggests that only moderate development can be expected. More precise definition of the extent and hydrologic character of the aquifer is needed.

HYDROLOGIC ATLAS OF MARYLANO AOUIFER MAP SERIES MAP VII

AOUIFERS OF THE COASTAL PLAIN - PINEY POINT FORMATION

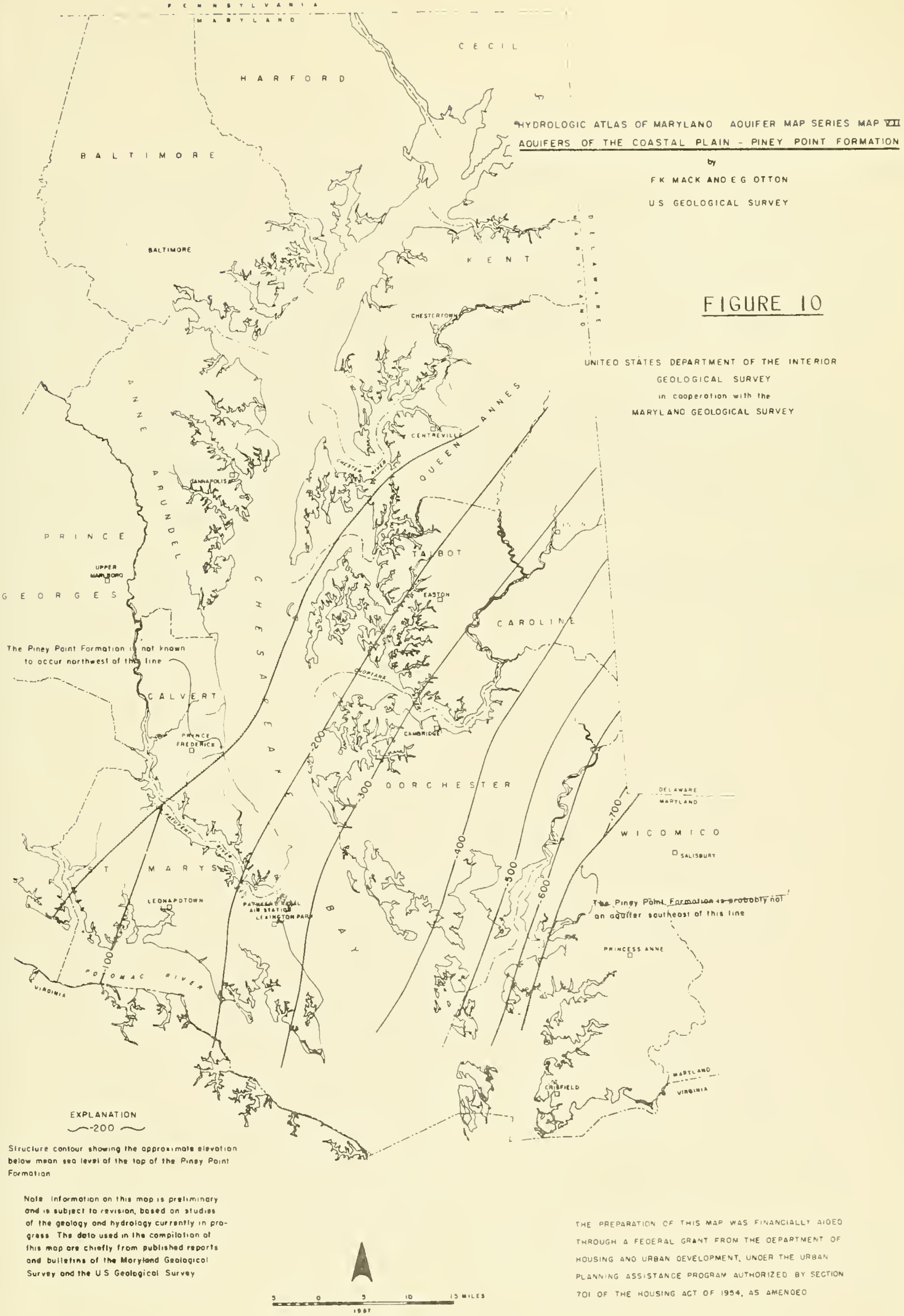
by

F K MACK ANO E G OTTON

U S GEOLOGICAL SURVEY

FIGURE 10

UNITEO STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLANO GEOLOGICAL SURVEY



EXPLANATION

-200

Structure contour showing the approximate elevation below mean sea level of the top of the Piney Point Formation

Note Information on this map is preliminary and is subject to revision, based on studies of the geology and hydrology currently in progress The data used in the compilation of this map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

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YORKTOWN FORMATION - MANOKIN AQUIFER

The Manokin aquifer (Figure 11) part of the Yorktown Formation, is an important aquifer in Somerset, Wicomico, and Worcester counties. It consists of gray, medium- to fine-grained sand and commonly ranges in thickness from about 90 to 200 feet. In many places the sand is overlain and underlain by silt, clay, and very fine sand which cause artesian or confining conditions and produce flowing wells in some localities. The yields of the most productive wells tapping the Manokin aquifer range from less than 100 to over 1,000 gallons per minute (gpm), although most public supply well yields are in the 300 to 400 gpm range.

The Manokin aquifer is a source of water for municipal and/or industrial supplies in Ocean City, Snow Hill, Princes Anne, and Salisbury. It is also used as a ground-water source in the southeastern part of Sussex County, Delaware. The chemical character of the water varies widely within the area. In places, it may be mildly acidic and/or high in iron content; in other places, such as Pocomoke City and Crisfield, it contains more than 200 parts per million parts of chloride.

The Manokin is capable of additional development in some localities, but in others it is not likely to be used because of the undesirable chemical character of the water.

HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP VIII

AQUIFERS OF THE COASTAL PLAIN - MANOKIN AQUIFER

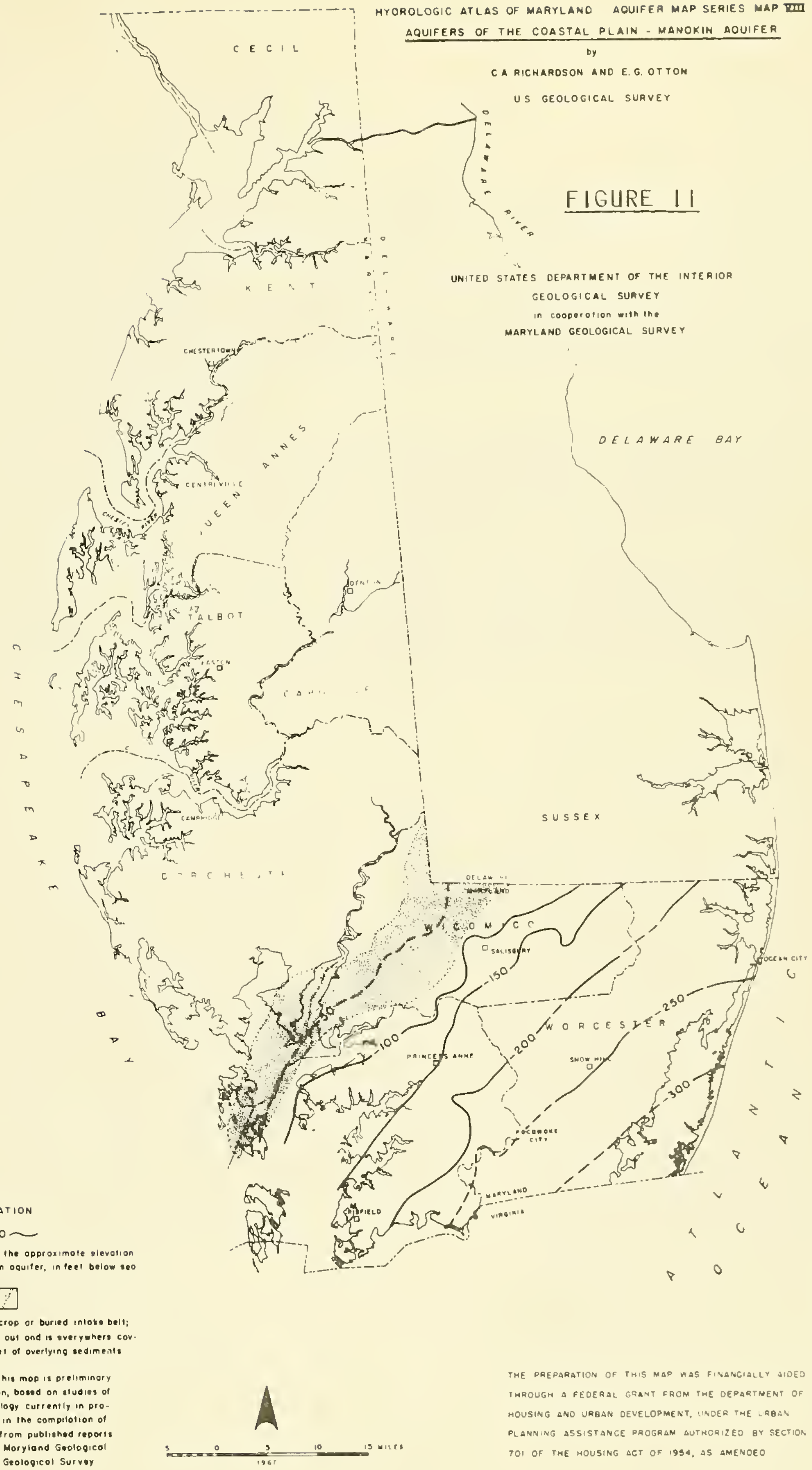
by

C A RICHARDSON AND E. G. OTTON

US GEOLOGICAL SURVEY

FIGURE 11

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY



EXPLANATION

-200-

Structure contour showing the approximate elevation of the top of the Manokin aquifer, in feet below sea level

▨

Approximate area of subcrop or buried intake belt; the aquifer does not crop out and is everywhere covered by at least a few feet of overlying sediments

Note Information on this map is preliminary and subject to revision, based on studies of the geology and hydrology currently in progress The data used in the compilation of this map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

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YORKTOWN FORMATION - POCOMOKE AQUIFER

The Pocomoke aquifer, (Figure 12) a part of the Yorktown Formation, is a major source of groundwater in Somerset and Worcester counties. It consists of gray, medium- to fine-grained sand interspersed with some gravel and thin lenses of clay. In many localities it is overlain and underlain by silt and clay, producing artesian conditions. Southeast of its intake belt the aquifer commonly ranges in thickness from 85 to about 145 feet. The yields of high capacity wells range from about 100 to about 660 gallons per minute (gpm). Generally, wells yielding more than 500 gpm appear to be exceptional.

The Pocomoke aquifer furnishes water for municipal and/or industrial supplies at Pocomoke City, Ocean City, and Crisfield. Locally, iron content of the water is high. The water is moderately soft to moderately hard (hardness range of 60 to 120 parts per million). In places treatment for iron removal may be required for many uses of the water.

The Pocomoke is capable of furnishing large additional supplies of groundwater throughout parts of Somerset and Wicomico counties and nearly all of Worcester County, but its potential may be restricted in some localities by the hazard of salt-water intrusion.

HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP IX

AQUIFERS OF THE COASTAL PLAIN - POCOMOKE AQUIFER

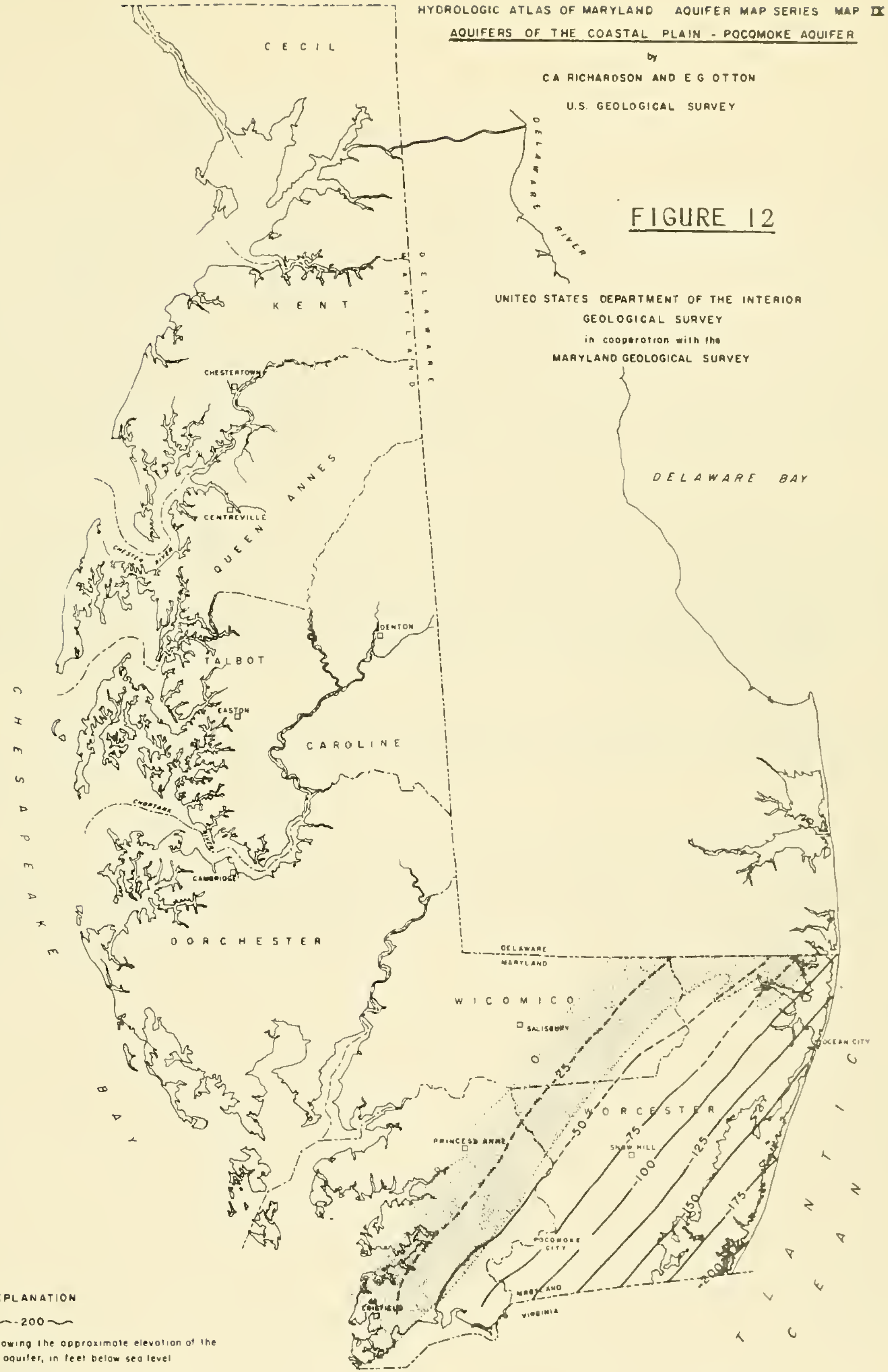
by

C A RICHARDSON AND E G OTTON

U.S. GEOLOGICAL SURVEY

FIGURE 12

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY



EXPLANATION

-200

Structure contour showing the approximate elevation of the top of the Pocomoke aquifer, in feet below sea level

Approximate area of subcrop or buried intake belt, the aquifer does not crop out but is everywhere covered by at least a few feet of overlying sediments

Note Information on this map is preliminary and is subject to revision, based on studies of the geology and hydrology currently in progress The data used in the compilation of this map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

THE PREPARATION OF THIS MAP WAS FINANCIALLY AIDED THROUGH A FEDERAL GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE URBAN PLANNING ASSISTANCE PROGRAM AUTHORIZED BY SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED

DEPOSITS OF PLIOCENE AND PLEISTOCENE AGE

The deposits of the Pliocene and Pleistocene age (Figure 13) comprise the major aquifer throughout most of the Eastern Shore counties. They are currently present in all of the Eastern Shore Counties and in some localities in the Southern Maryland counties, but there they are not an important aquifer. They consist of yellowish to tan and white sand and gravel with some layers of silty clay and clay and range from a few feet to about 220 feet thick in an area north of Salisbury. High water-table conditions generally prevail throughout the area of their occurrence. The yields of wells tapping the more permeable sand and gravel on the eastern Shore range as high as 4,000 gallons per minute (gpm), and it is probably that even more productive wells can be constructed in the more faborable localities.

The Pleistocene deposits are the source of water supply for the towns of Salisbury, Berlin, Mardela Springs, Barclay, and other smaller communities. At Salisbury, supplies of several millions of gallons a day have been developed from these deposits by means of large-diameter wells, 40 to 60 feet deep. Generally, the water is of good chemical quality but locally treatment for iron removal and de-acidification is necessary.

In Queen Anne's Dorchester, and Wicomico counties individual irrigation wells are known to yield more than one million gallons a day (mgd), but as this use is seasonal and dependent on climatic conditions, it represents no major draft on the aquifer.

The quantity of water available from the Pleistocene desposits is estimated to be many times greater than their current (1966) rates of pumpage. These deposits are potentially the most productive aquifer in Maryland and capable of extensive development.

HYDROLOGIC ATLAS OF MARYLAND AQUIFER MAP SERIES MAP X

AQUIFERS OF THE COASTAL PLAIN - DEPOSITS OF PLIOCENE (?) AND PLEISTOCENE AGE

by

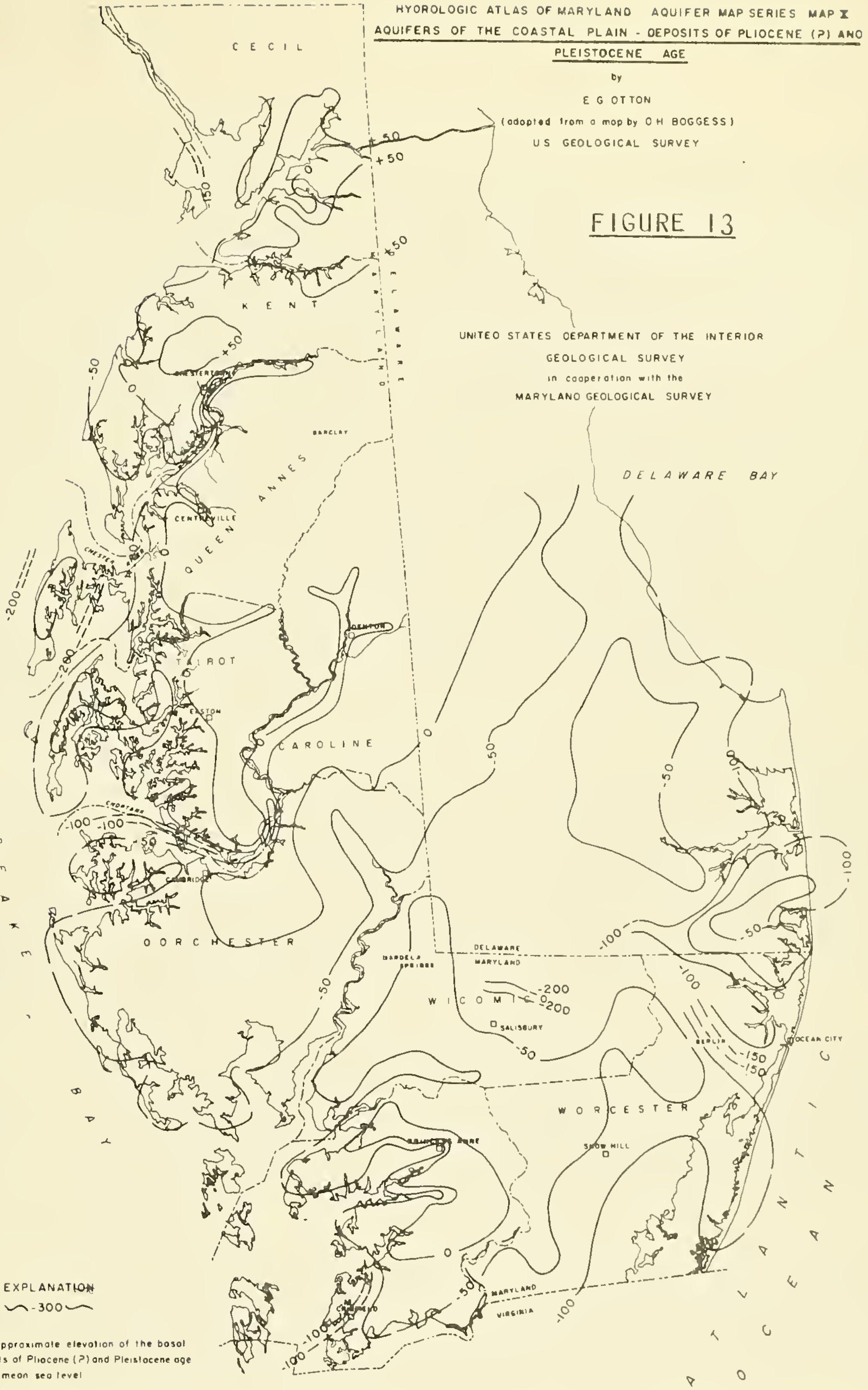
E G OTTON

(adapted from a map by O H BOGGESS)

U S GEOLOGICAL SURVEY

FIGURE 13

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
in cooperation with the
MARYLAND GEOLOGICAL SURVEY



EXPLANATION

-300

Contour showing the approximate elevation of the basal surface of the deposits of Pliocene (?) and Pleistocene age in feet above or below mean sea level

Note Because the deposits are not an important aquifer in the Southern Maryland Counties, they are not mapped in that part of the State. Information on this map is preliminary and subject to revision, based on studies of the geology and hydrology currently in progress The data used in the compilation of the map are chiefly from published reports and bulletins of the Maryland Geological Survey and the U S Geological Survey

THE PREPARATION OF THIS MAP WAS FINANCIALLY AIDED THROUGH A FEDERAL GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE URBAN PLANNING ASSISTANCE PROGRAM AUTHORIZED BY SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED

C. Data Inputs for Aquifers

The maps for engineering geology, drawn on the scale of 1:63,360 (1 inch=1 mile), are designed also to be used with this aquifer report. This can be done because of the correspondence between these two natural phenomena. With the assistance of the Maryland Geological Survey, the geologic formations have been correlated with the aquifers. Aquifer systems relate to geological formations such that the latter can be used to locate aquifer recharge areas or other water storage rock types. To be more accurate, however, aquifers relate directly to lithographic horizons within the geologic formations, the latter being defined in periods of time, on the basis of biological remains, lithology and structural relationship. The aquifer maps show the individual recharge areas only for Maryland' coastal plain. The maps of the Piedmont and Western Maryland simply illustrate all areas of the same relative water storage ability. These unites are based on yield estimates generated by the wells in the areas. A systematic aquifer study including field work has as yet not been accomplished for these two areas. An effort of that type would require a substantial allocations of manpower and is beyond the scope of this study. Therefore, even in view of the inadequacies of this data it has been incorporated into the Maryland Generalized Land Use Plan because it is the best information available.

The following charts enable one to convert the engineering geology formation into aquifer systems and aquifer recharge areas, (Tables 4 and 5). The conversion factor that makes this possible is the numbering system developed for computer encoding purposes. The four digit encoding number developed from a two digit county prefix and a two digit formation number is broken into two parts. The county names and prefix numbers are arranged horizontally, for the aquifer systems chart and vertically for the recharge areas chart. In both cases, the numbers which appear in the body of the table are the formation numbers originally assigned on a county basis for the engineering geology maps.

Consulting the engineering geology tables in section one for any county will give you the name, description and characteristics of that formation within the county. One must remember that if the same formation exists in two or more counties, it may or may not have the same formation number. The encoding system is not capable of systematizing this relationship because of the sequential nature of the original mapping done in the mid 1960's.

With the assistance of these two charts one can "map" the hydrologic units and aquifer recharge areas on a county, regional, or statewide basis. One simply takes the geographic unit to be studied, locates the formations or hydrologic units by name and records the formation numbers for each county, and then consults the map series for a graphic representation.

Table 4

PIEDMONT AND WESTERN MARYLAND AQUIFER SYSTEMS
(and Recharge Areas)

County	Prefix Number	Hydrologic Unit I	Hydrologic Unit II	Hydrologic Unit III
Allegany	01	05,06	10,11,12,14	01,02,03,04,07, 08,09,13,15
Baltimore	04	03	05,06	01,02,04,07-13
Carroll	07	06,13	08,10,11	01-05,07,09, 12,14,15
Cecil	08			01-07
Frederick	11	05,14,15	02,03	01,04,06,07, 10-13,16-19, 20-22*
Garrett	12		03,04,05,07	01,02,06,08
Harford	13	03	02,04	01,05-10
Howard	14	03	05,06	01,02,04,07-13
Montgomery	16		02	01,03-11,14*,15*
Washington	22	06,08-11, 16,17	01,21	02-05,12-15,18-2, 22-24*

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* These units are alluvium which cover the bed rock. The bed rock postulated to be beneath these should be considered the aquifer for the area involved.

Table 5

COASTAL PLAIN AQUIFER RECHARGE AREAS

Aquifer Formation	Anne Arundel (02)	Baltimore (04)	Calvert (05)	Caroline (06)	Cecil (08)	Charles (09)	Dorchester (10)	Harford (13)	Howard (14)	Kent (15)	Montgomery (16)	Prince George's (17)	Queen Anne's (18)	St. Mary's (19)	Somerset (20)	Talbot (21)	Wicomico (23)	Worcester (24)
Patuxent	01	14			08/ 10			11	14		12	01						
Patapsco	03	15			09/ 10			12			13	02						
Raritan	04	17			11					01								
Magothy	04									01								
Aquia	06				13	01				02		05						
Nanjemoy	06											06						
Piney Point o	06											06						
Manokin #							02										02	
Pocomoke #															02		03	02
Pleistocene Deposits +				02/ 03	15	03	01/ 02			04			02/ 03	03	01/ 02	02/ 03	01, 02, 03	01/ 02

+ Recent sands and gravels covering most of Eastern Shore. Include most formations of the Columbia group (Bryn Mawr, Sunderland, Wicomico, Talbot, Pimlico).

# The Monokin and Pocomoke aquifers do not outcrop but are feed through permeable sands overlaying them.

o The Piney Point aquifer does not outcrop but is recharged through the Nanjemoy formation which does outcrop. Both are shown on the chart and operate as a unit.

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Note: The Maryland Department of Geology, Mines and Water resources was renamed Maryland Geological Survey in 1964.

Minerals

III MINERALS

A. Introduction

The spatial distribution of mineral resources across the state forms the third section of this manual. An attempt has been made to locate both surface and sub-surface mineral deposits by employing the Engineering Geology maps developed in the 1960's as a starting point. We are able to do this because of the high correlation between mineral outcrops and geological formation.

Although Maryland possesses a plentiful supply of mineral resources, their availability in the amounts necessary, especially for construction, is threatened through preemption by urban development rather than through depletion. The rapid growth of the State's population, especially in the metropolitan areas of Baltimore and Washington, D.C., is the prime reason for the increased demand and resulting need for increased production of these minerals. It is also responsible for the spread of urban development over many acres of mineral-bearing lands, thus bringing about conflicts in land use; hence, information about the State's mineral resources has been included in the capability analysis of the Maryland Generalized Land Use Plan.

An attempt must be made to define those areas that harbor mineral resources even if the present feasibility of extraction is not high. The encroachment of today's urban development upon a potential extractive site will deprive future generations of needed resources. Even if these sites have little resource value at present, a future increase in local demand, or the depletion and preemption of other richer deposits, or the increase in value of a commodity could promote a profitable operation.

The supply and availability of mineral resources are dependent upon a number of factors which may be grouped into three categories: geological, economic, and sociological.

Geology is perhaps the most important factor and is the one which is not under human control. Mineral deposits are emplaced by geological processes and a mineral extracting operation must therefore be located where the resource occurs, unlike other industries which do not have this limitation. The only alternatives to locating a mineral extracting operation at a particular place is to locate it elsewhere within the area of occurence of the same or a similar mineral deposit.

The State of Maryland is fortunate to have good geological maps at a scale of one inch equals one mile for all counties except those of the lower Eastern Shore region. The Maryland Geological Survey, with the information at its disposal, is able to delineate broad areas within the mapped counties where potential mineral resources are likely to be found.

Economic factors affecting the supply and availability mineral resources are controlled by the laws of supply and demand and are only partially influenced by human activities. These factors require that the mineral deposit be mined at a profit. Thus, the grade must be a quality fit to be mined at a profit. Thus, the grade must be a quality fit to mine; the size of the deposit must be large enough to allow the company to operate long enough to realize a return on its investment in land, equipment, etc.; and the potential market must not be so far from the mineral deposit that the transportation costs become excessive.

Sociological facts affecting the supply of minerals are those which are entirely under human control and are under the direction of those segment of the population that are not concerned with the production or consumption of the mineral resource. These factors, including zoning, urbanization, environmental consciousness and legislation can be no less powerful than the geological and economic ones in determining the availability of mineral resources. Zoning regulations may limit mineral extracting industries to certain areas and exclude them from others. Urbanization not only pre-emps mineral-bearing lands for other development uses prior to the rise of local demand for the resource, but also involves contemporary competition for the land, whereby the mineral industry must compete with other potential users of the land. Environmental consciousness is concerned with the impact of a mineral extracting operation on the environment in terms of such factors as aesthetic value, noise, erosion, pollution, and reclamation. Legislation may be regarded as the end result of environmental consciousness whereby limitations and controls are placed upon the mineral industry.

An example of how these three factors (i.e. geology, economy, and sociology) inter-relate to affect the supply and availability of mineral resources would be as follows: Urban residential and industrial development along the Maryland portion of the Washington-Baltimore-Wilmington corridor, coupled with the establishment of governmental and military reservations and parklands, has rendered a large part of the best sand and gravel lands unavailable for mineral extraction. The best sources of crushed stone in close proximity to this development corridor are also being encroached upon. Large areas of stone suitable for crushed stone aggregate are present in Frederick and Washington Counties; however, they are far removed from the areas of greatest demand and the transportation costs are excessively high. Development in these areas is also encroaching upon the local mineral deposits. The acreage of sand and gravel and stone still remaining, and unoccupied by non-compatible development, undoubtedly contains much land where the deposit is too thin or otherwise of unsatisfactory quality or economic grade to exploit. Therefore, the actual available acreage is considerably less.

The production and consumption of sand and gravel has risen from 3.5 million tons in 1940 to 13 million tons in 1970, while that of stone rose from 1.1 million tons in 1940 to 16 million tons in 1970. Based on the population statistics the per capita consumption of sand and gravel aggregates in Maryland in 1940 was 2.19 tons per person. This rose to 3.34 tons per person in 1950, to 5.81 tons per person in 1960, and to 7.47 tons per person in 1970. The average rate of increase in aggregate production over the past 25 years has been approximately one million tons per year. Assuming the same rate of increase for both aggregate production and the population, the requirements for aggregates in the State of Maryland by the year 2000 are projected to be 60 million tons per year, or approximately 9 tons per person. The cumulative demand for aggregates from 1970 to 2000 is estimated to be 1,335 million tons, all of which must be supplied from local deposits.

B. Mineral Resources - Supply and Availability in Maryland

In May, 1969 the Department of State Planning published Ground Aquifers and Mineral Commodities of Maryland, the second part of that document, describingthe major mineral resources in the State, was authored by Dr. Johnathan Edwards, Jr. and is excerpted in the following pages.

1. Introduction

Since the earliest days of settlement, mining has been a part of the economic life of Maryland. The State was once the leading producer of chromium ores in the world and has also been an important producer of iron, copper, and coal. Other mineral deposits which have been of past significance include: gold, diatomaceous earth, feldspar, flint quartz, and mineral pigments.

During the 20th century, the mining of sand and gravel and crushed stone aggregates has increased spectacularly primarily due to the advent of the automobile and the demand of motorists for good all-weather roads. Coupled with this has been an ever-increasing number of large private and public construction projects, such is large buildings, dams, and airports, which have also consumed immense quantities of sand and gravel, crushed stone, and cement.

The production of the industrial minerals, principally sand and gravel, crushed stone, Portland cement, and clay, and of the fuels, including coal and natural gas, comprises the mineral industry in Maryland today. While there is less a variety of minerals being produced at the present time, the volume and value of production are considerably greater than in the past. The mining industry has experienced a very significant growth rate since World War II. In addition to inflationary factors, this growth is mainly attributable to the growth in population over the same period which accelerated the demand for more roads, homes, services, industries, etc.

The rapidly growing population, with its increased affluence and mobility, has resulted in a great expansion of all population centers in Maryland, especially the metropolitan areas of Washington, D.C., and Baltimore. The expansion of the population centers in Maryland has brought about two problems for the mineral industry: one, a rise in the competitive uses of the land, with the very real danger of permanent loss of mineral resources; and two, a rise in consciousness and concern about the environment, with the prospect of increasing governemtnal control and regulation of the mineral industry.

2. Surface Mining in Maryland

Surface mining, variously called open-pit, open-cut or strip mining, can be defined as mining activity at or near the surface of the earth in which the mineral deposit can be exposed and removed by conventional excavating equipment and methods, it is different from underground mining which include not only the active pit, but also abandones pits, land occupied by stockpiles, processing and treatment plants, waste and overburden disposal areas, settling ponds, and access roads. Underground or deep mining, where the mineral deposit is not exposed at the surface by the mining operations, is, except for the mining of coal, of negligible concern in Maryland. The few underground mines which exist in mineral deposits other than coal are operated as underground extensions of surface mines.

Surface mining in Maryland can be classified into four types: strip coal mines, quarries in consolidated rocks, pits in unconsolidated rock formations, and dredging operations. Each of these types of mining has certain physical conditions which are peculiar to it and which are determined by the geology of the mineral deposit and by the economics of the mineral industry.

Strip Coal Mines:

Strip coal mines involve the mining of coal from surface or near-surface seams and in Maryland are restricted to the coal basins of western Allegany County and Garrett County. The soil, layers of sandstone and shale, and thin beds of uneconomic coal which overlie the target seam of economic coal comprise the overburden, which is removed and stockpiled by dragline or other earthmoving equipment. Because coal has a relatively high unit value, averaging $4.87 per ton for strip mined coal in 1970, the volume of overburden which may be economically stripped off may be several times the volume of the coal removed. In Maryland the present limit to the thickness of overburden which can be conomically removed is approximately 70 feet. After the overburden reaches this depth, the coal is often mined by augering the seam for a distance of up to 200 feet into the mine face.

As strip coal mines in Maryland follow the outcrop of the coal seam across the face of a hillside, the mines tend to be long and narrow, covering only several tens of acres, rather than spread over hundreds of acres as in the midwestern states. In Maryland, the economic seams of coal are between 2 and 10 feet in thickness, with the average around 3 feet. Therefore, strip coal mining affects relatively a large area of land in relation to the total tonnage of coal produced from each mine. Also, the economic life of strip c oal mines is short as the coal seams at each mine are generally depleted after several years of operation.

Without proper controls, strip mined lands are a source of sediment pollution and acid mine drainage. However, with proper controls during the operating life of a strip mine and proper reclamation after completion, the mined area can be returned to its former use, such as forest or agriculture.

Quarries:

Quarries are surface mines in consolidated rocks and are found in the Piedmont and Appalachian regions of Maryland, that is, in all parts of the State west of the Coastal Plain. Building stone, talc, soapstone, shale for brick manufacture, and crushed stone for use as aggregate and Portland cement are produced from quarries. These materials have a low unit value and consequently the thickness of overburden must be at a minimum. The overburden, usually soil and decomposed rock, is removed with earthmoving equipment unless pinnacles and boulders of bedrock are present, which must then be drilled, blasted, and removed. The deposit itself is then drilled and blasted, and removed. The deposit itself is then drilled and blasted, crushed, and screened to make varying sized products according to their ultimate use.

The size of a quarry is large, usually several tens of acres, as the operator has invested a considerable amount of money in equipment and expects to be in business for several decades at least. The largest quarry in the State covers approximately 60 acres, excluding land occupied by the processing plant, stockpiles, and other facilities. However, a number of factors cause a quarry to affect a comparatively small area of land surface in relation to the tonnage of material produced. Most rock deposits are generally thick an esten to great depths in the earth. Consequently the operator does not have to acquire more land and spread laterally to continue mining, but can continue at deeper and deeper levels in the same place. There is, however, an economic limit to the depth at which a quarry can be worked depending on haulage grades, ground water influx, and safety. Ground water influx in quarries is usually, but not always, less of a problem than in pits in unconsolidated rock formations, due to the lesser permeability of the rock. Water does enter quarries along bedding planes and fractures and through solution channels, but the inflow can usually be controlled with pumps. Heavy pumping will have an adverse effect on the ground water table in the vicinity of the quarry.

Pits:

Pits in unconsolidated rock formations are found primarily in the Coastal Plain area in Maryland but also may be located elsewhere in the State in any unconsolidated surficial material. Sand and gravel, clay, peat, diatomaceous earth, and greensand marl are obtained from pits. Because of the unconsolidated nature of these materials, they may be excavated with earthmoving equipment such as bulldozers, backhoes, and draglines without drilling and blasting. These materials also have a low unit value and require that the thickness of overburden, usually consisting only of soil, be at a minimum in relation to the volume of material to be extracted.

As the deposits of industrial minerals in the unconsolidated sedimentary rocks or surficial materials tend to be thin, the pits must spread laterally as mining progresses. Consequently, a relatively large area of land will be affected per ton of material produced.

Dredging Operations:

Dredging operations involve the removal of unconsolidated materials from a submerged location, most often from rivers and swamps, but also may include removal of land-based deposits situated below the ground water table. The desired materials are dug from the bottom by bucket chain or scraper and transferred by endless belt to a washing plant. The material is then screened, with the coarser fraction sent to the stockpile and the fines washed out and returned to the water as waste. As with the subaerial unconsolidated deposits, the submerged ones are thin and require a large area to be mined per ton of product recovered. The economic life of the operation depends on the size and extent of the deposit.

3. Minerals of Present Importance and Future Potential

Non-metallic minerals, the industrial minerals and fuels, comprise the total output of the mineral industry in Maryland today. The most important mineral commodities are sand and gravel, crushed stone, and Portland cement, which together account for about 85 percent of the total annual value of mineral production.

The fuels, coal and natural gas, make up about 10 percent of the annua value of mineral production, but the supply and availability of these will not be discussed in this report. The State of Maryland already has legislation which places controls on the exploration for and the production of natural gas, which is not mined but is produced from wells (see Annotated Code of Maryland, Art. 66C, sec. 675-689). The supply and availability of coal has been studied and a report entitled *Coal Possibilities in Garrett and Allegany Counties, State of Maryland*, prepared by John T. Boyd and Associates, was presented to the State of Maryland in 1964.

The remaining five percent of the annual value of mineral production is made up of clay and shale, peat, talc and soapstone, greensand marl, masonry cement, lime, and potassium salts. Mineral commodities for which there appears to be a potential future importance include lightweight aggregate and diatomaceous earth.

Aggregates:

Sand and gravel and crushed stone are largely interchangeable for use as aggregates. Each has certain favorable and unfavorable qualities which must be weighed against any particular application. The individual particles of sand and gravel are usually rounded in shape, while those of crushed stone are angular. A sand and gravel deposit is often of limited thickness and the quality of the material may show considerable variation due to the elnsatic nature of the deposit. Deposits of stone are usually large generally uniform in composition and texture. Low-dipping and sedimentary rocks may extend laterally for considerable distances, while steeply-dipping sedimentary rocks or igneous and metamorphic rock bodies extend downward to great depths. Washing of sand and gravel is often required to remove undesirable fines, and the waste water must be stored in settling ponds before it can be discharged. The blasting and crushing necessary for the preparation of crushed stone produces such undesirable effects as noise, vibration, and dust. Sand and gravel does not require drilling, blasting, and crushing but can be removed by earthmoving equipment such as power shovels, backhoes, and draglines, resulting in lower production costs and a lower final cost per ton than stone.

Prepared aggregates, such as lightweight aggregate manufactured from clay or shale, will probably become of increasing importance as the supply of local stone and sand and gravel diminishes. Blast furnace slag, a by-product of steel making, is essentially a manufactured aggregate and at the present time is used widely in the Baltimore area.

Sand and Gravel:

Sand and gravel is present in Maryland in four different geological formations: the Patuxent formation, the Brandywine Formation, river terrace gravels, and gravel lenses on the Eastern Shore.

The most important source of sand and gravel in the State is the Patuxent Formation of Cretaceous age which occurs along the western edge of the Coastal Plain from Cecil County to Washington, D.C. This formation represents an ancient series of coalescing river deltas, and the economic deposits of sand and gravel occur as beds and lenses interbedded with non-economic layers of sand, silt, and clay. Layers and nodules of iron-cementec sandstone also are present. This formation is being mined in Cecil, Harford, Baltimore, and Prince George's Counties. It is the largest source of sand and gravel supplied to the Baltimore metropolitan area and is also a major source for the Washington area.

The second most important source of sand and gravel is the Brandywine Formation of Pliocene age in southern Maryland. This formation occurs as a blanket of sediments, 30 to 60 feet thick, which covers the level, plateau-like upland surface of southern Prince George's, Charles, St. Mary's, and southern Calvert Counties. The gravels are best developed in the northwestern part of the area in Prince George's County and both the thickness of the deposit and the coarseness of the gravels diminishes toward the south and east. It is being mined at present in Prince George's and Charles Counties for use in the Washington Metropolitan area and also in St. Mary's County for local use.

The river terrace and channel gravels of Pleistocene to Recent Age are of least importance as a source of sand and gravel. Although these gravels are found along most of the major streams in the Coastal Plain, Piedmont, and Appalachian regions, the only area where they are being extensively mined at present is along the valley of the Patuxent River in Anne Arundel and Prince George's Counties. Other terrace gravels occur along the Potomac River, the Monocacy River, and Antietam creek.

Submerged Recent gravel deposits have been dredged from the estuaries of the Potomac River in Charles County and the Northeast River in Cecil County and from the channel of the Pocomoke River between Somerset and Worcester Counties.

Crushed Stone:

Rock suitable for crushed stone is present in a number of geological formations throughout the Piedmont and Appalachian regions of Maryland. Because of the geological complexity of these regions, a variety of rock types are found, including gabbro, serpentine, basalt, gneiss, granite, limestone, dolomite, marble, sandstone, and quartzite, all of which are used for crushed stone. However, there is a considerable range in chemical and mineralogical composition among these rock types. Some rocks may be desired for special uses which require a specific composition or a high degree of purity, while others may be excluded from certain uses by limiting minimum standards for chemical and physical properties.

Igneous and metamorphic rocks which have a mafic composition, that is, containing a large proportion of magnesium- and iron-bearing minerals, are present throughout the Piedmont region in Maryland. These rocks including gabbro, serpentinite, mafic gneiss, basalt, and granitic rocks, make aggregate stone of superior quality because of their toughness, uniformity of texture, and inert chemical nature. Gabbro and related rocks occur in a wide belt which extends from western Cecil County through central Harford County to eastern Baltimore County. Other large bodies of gabbroic rocks are present in eastern Harford County and from southern Baltimore County to eastern Howard County. Several small bodies of gabbro are in Montgomery County. Gabbro is quarried for crushed stone in Baltimore, Harford, and Howard Counties.

Serpentinite, a softer mafic rock than gabbro, occurs in narrow, elongate bodies in westernCecil County and across northern Harford County through Baltimore and Howard Counties to Montgomery County. Some serpentinite occurs with the gabbroic rocks in Baltimore and Harford Counties. Crushed stone is produces from quarries of serpentinite in Baltimore and Montgomery Counties.

Mafic gneiss occurs from Cecil County to eastern Harford County, and also in Montgomery County, west of Washington, D.C. It is quarried for crushed stone in Harford County. Basalt, sometimes called diabase or trap rock, occurs in large, tabular sills in western Montgomery County and in extreme northern Frederick County. Although basalt makes excellent crushed stone, it is not being mined in Maryland at the present time.

Granitic rocks are those igneous and metamorphic rocks which have a composition high in silica-bearing minerals, such as quartz and feldspar. They include the true granites as well as granodiorite, diorite, and the granitic gneisses. In general, these rocks are coarser-grained than the mafic rocks and contain minerals such as feldspars and the micas which break or cleave easily. Consequently, crushed stone made from these rocks does not make as good an aggregate stone as does crushed stone made from the tougher mafic rocks.

Granitic rocks occur throughout the eastern Piedmont region from Cecil County southwestward to Washington, D.C. The largest mass of granitic rocks is the Port Deposit granite or granitic gneiss which is present throughout much of northern Cecil County and extends across Harford County to eastern Baltimore County. Other bodies of granitic gneiss occur in easterr Montgomery County.

Carbonate rocks, which include limestone, dolomite, and marble, are rocks composed principally of calcite and dolomite, the calcium carbonate and calcium-magnesium carbonate minerals. These rocks are not so hard or tough as the igneous rocks and therefore their crushing equipment requires less maintenance expense. Thick- or massively-bedded deposits make excellent crushed stone, as the rock has uniform texture and breaks into equidimensional particles. Crushed stone made from the carbonate rocks accounts for about 65 percent of the total volume of crushed stone production in Maryland. About 20 percent of the crushed stone produced from high-calcium carbonate rocks is used for the manufacture of Portland cement. Some is also ground for agricultural lime or burned for quick or hydrated lime. Carbonate rocks of special composition and purity may be put to other specific chemical or metallurgical uses.

Limestone and dolomite are bedded sedimentary rocks and occure in a number of geologic formations in the western Piedmont and Appalachian regions. The largest areas of outcrop are in the Hagerstown Valley of Washington County and the Frederick Valley of Frederick County. Small areas of occurence are in western Washington County, central and western Allegany County, and locally in Garrett County, particularly in the vicinity of Deep Creek Lake. Quarries for the production of crushed stone from limestone and dolomite are located in each of these four counties.

Marble is a metamorphic rock similar in chemical composition to limestone and dolomite but its texture and the mineralogy have been altered and recrystallized. Two marble formations occur in the Piedmont of Maryland: the Cockeysville Marble in western Harford, central Baltimore, central Howard, and extreme southeastern Carroll Counties; and the Wakefield Marble in western Carroll and eastern Frederick Counties. The cockeysville marble is quarried for crushed stone in Baltimore and Howard Counties and pure calcite marble layersin the stone are used to make white aggregate, roofing granules, white mineral filler, and ground agricultural limestone.

Since 1960, it is estimated that about 2,500,000 tons of oystershell have been dredged from buried or fossil deposits, called "reefs," in the Chesapeake Bay. Most of this has been purchased by the State of Maryland to rehabilitate existing oyster bars and to establish new oyster-producing beds by creating a firm bottom substrate on which the oyster spat may attach. Additional production has been sold for use as crushed stone, poultry grit, and ground agricultural lime.

Sandstone is a rock consisting of tightly-cemented quartz sand, whereas quartzite is a sandstone in which the grains have been fused together by metamorphism. Pebbly sandstone is quarried and crushed for sand and gravel in Garrett County. Quartzite quarried in Frederick County is used in the manufacture of Portland cement. Up to a few years ago, sandstone was mined in Allegany County to produce ferrosilicon. A pebbly conglomerate, or cemented gravel, in Frederick and Carroll Counties may be of future importance as a source of aggregate.

Because the hardness of the individual quartz grains causes excessive wear on the crushing equipment, sandstone and quartzite are not generally used for crushed stone, unless the rock can be easily crushed by breaking the cementing bond between the grains. These highly siliceous rocks can probably be best used for other purposes. Some of the sandstone in Allegany and Washington Counties, and perhaps some of that in Garrett and Frederick Counties, is of a purity suitable for glass manufacture.

Aggregate Supply and Demand:

Not counting the local gravel deposits in the counties on the Eastern Shore, there are approximately 551,000 acreas bearing sand and gravel in Maryland, distributed as shown in Table 6.

Approximately 518,000 acres of land contain stone suitable for crushed stone in Maryland. These are distributed among the counties as shown in Table 7.

Portland Cement:

Approximately 15 percent of the crushed stone production in Maryland goes into the manufacture of Portland cement. The principal ingredient for Portland cement, accounting for about 80 percent of its composition is limestone or marble, which must have the specific chemical quality of low magnesia content. The rock may contain shale or other clayey matter to the extent that it is called "cement rock." The Wakefield Marble at Union Bridge, Carroll County, The Grove Limestone at Lime Kiln, Frederick County, and the Stonehenge Limestone at Security, Washington County, are mined for the production of Portland cement. Shale, sandstone, and other rock ingredients

Table 6

ESTIMATES OF THE AVAILABLE LAND BEARING SAND AND GRAVEL IN MARYLAND, 1971

County	Total Acres	Percent Lost thru development	Acres Remaining
Anne Arundel	19,000	40%	11,400
Baltimore	20,000	75%	5,000
Baltimore City	11,000	95% or more	550
Calvert	45,000	5%	42,750
Cecil	22,000	55%	9,900
Charles	160,000	5%	152,000
Harford	21,000	70%	6,300
Howard	14,000	85%	2,100
Montgomery	9,000	85%	1,350
Prince George's	115,000	55%	51,750
St. Mary's	115,000	10%	103,500
		Total	386,600

Table 7

ESTIMATES OF THE AVAILABLE LAND BEARING STONE SUITABLE FOR CRUSHED STONE IN MARYLAND, 1971

County	Total Acres	Percent Lost thru development	Acres remaining
Allegany	45,000	20%	36,000
Baltimore	70,000	75%	17,500
Baltimore City	16,000	95% or more	800
Carroll	5,000	15%	4,250
Cecil	50,000	20%	40,000
Frederick	52,000	50%	26,000
Garrett	10,000	50%	5,000
Harford	60,000	10%	54,000
Howard	22,000	80%	4,400
Montgomery	13,000	25%	9,750
Washington	185,000	15%	157,250
		Total	354,250

Portland Cement:

Approximately 15 percent of the crushed stone production in Maryland goes into the manufacture of Portland cement. The principal ingredient for Portland Cement, accounting for about 80 percent of its composition is limestone or marble, which must have the specific chemical quality of low magnesia content. The rock may contain shale or other clayey matter to the extent that it is called "cement rock." The Wakefield Marble at Union Bridge, Carroll County, the Grove Limestone at Lime Kiln, Frederick County, and the Stonehenge Limestone at Security, Washington County, are mined for the production of Portland cement. Shale, sandstone, and other rock ingredients are added to the limestone or marble to provide the proper ratios of lime, silica, alumina, and iron. These rock materials are then ground to a fine powder and burned together in a kiln, which fuses the mixture into Portland cement clinker. This clinker is then finely ground to produce Portland cement.

Portland cement is a manufactured product and as such has a higher unit value than crushed stone or sand and gravel. Therefore, it is economically possible to transport finished Portland cement over considerable distances.

Clay and Shale:

Clay and shale suitable for a wide range of ceramic and refractory uses are found throughout Maryland. Brick production in Maryland is now limited to a few high-volume producers. About 50 percent of the production of clay and shale in Maryland goes into the manufacture of bricks. Most of the remaining clay and shale production goes into the manufacture of lightweight aggregate and Portland cement. Less than two percent of the production is for fire clay, ball clay, stoneware clay, and clay for other miscellaneous uses.

Economically the most important sources of clay and shale are the deposits in the Arundel and Patapsco Formations of Cretaceous age along the western edge of the Coastal Plain. Brick clay is mined from two locations in Baltimore County and also from two locations in Prince George's County. Ball clay is mined in Baltimore County. Fire clay is produced in Harford County and was formerly produced in Cecil County.

Widely separated lenses of clay occur within the blanket of Pleistocen sediments on the Eastern Shore. Brick clay is mined near Chestertown, Kent County, and until recently near Salisbury, Wicomico County. The gettysburg and New Oxford Formations of Triassic age that occur in Carroll, Frederick, and Montgomery Counties contain shale beds suitable for brick and tile manurfacture. A quarry near Rocky Ridge, Frederick County, produces brick clay. Fire clay for refractory brick was formerly taken by deep mining methods from bedded clay deposits in the coal-bearing regions of western Allegany County and Garrett County.

The expanding urbanized area along the Washington-Baltimore-Wilmington corridor is rapidly encroaching or pre-empting much of the useable clay-bearing land in the western Coastal Plain. The Marlboro Clay in Prince George's, Anne Arundel, and Charles Counties is a potentially important source of clay for brick and tile for the Baltimore-Washington area.

Other Mineral Resources:

Other mineral resources mined in Maryland but which together account for less than five percent of the total value of mineral production are peat, talc and soapstone, and greensand marl. Reedsedge peat is dug from a bog near Betterton, Kent County, and both reed-sedge and humus peat come from near Bittinger, Garrett County. The potential exists for other peat-bearing bogs to be developed both in Garrett County and in the Eastern Shore counties, although production will undoubtedly remain on a small scale.

Deposits of talc and soapstone are associated with the bodies of serpentine which occue within the eastern part of the Piedmont area of Maryland.

Greensand marl, composed primarily of the mineral glauconite, was formerly produced in Kent, Anne Arundel, Prince George's, and Charles Counties for use as a low-grade fertilizer. The only production in recent years has come from a pit near Dunkirk, Calvert County, and the probability of future expansion appears to be low.

Diatomaceous earth occurs as a 20-foot thick bed at the base of the Calvert Formation in Calvert, Prince George's, and Charles Counties, which was at one time the only source of diatomaceous earth in the United States. There has been no local production for a number of years due to the development of the great diatomite deposits at Lompoc, California, and in other western states.

C. Data Inputs

1. Data Sources

Complete dependence was placed upon the data supplied by the Maryland Geological Survey and the U.S. Geological Survey for this capability variable Again since these scources have a high degree of credibility, little additional regional study was undertaken.

Maps have been drawn on the scale of 1:63,360 (1 inch=1 Mile); one should be cautioned that this mapping scale and the level of data applicabili are appropriate for the purposes of the Maryland Generalized Land Use Plan. If detailed information on the specific characteristics of a deposit is necessary, more on site investigation and more detailed mapping will be needed. Unless more detailed mapping on a larger scale is done, such as the 7½ minute topographic quadrangle maps with a scale of 2¼ inches to the mile, it will be very difficult to pinpont specific localities of potential deposits. To prove out any individual mineral deposit further requires a detailed series of chemical and physical tests in order to determine if the deposit is satisfactory for its intended use and also an extensive drilling program to delineate the three-dimensional form of the deposit in order to determine its volume and expected economic life. This latter exploratory activity is always the responsibility of individual mineral producers.

2. Data Conversion

After reviewing the different kinds of deposits found in the state, eleven major types of activities were mapped using the engineering geology maps as a base. By this we mean that the geologic formation boundaries were used to help locate productive mineral commodities or deposits with development potential. However, the geologic boundaries themselves were not mapped for minerals, as they were for geology and aquifers. Instead of formation boundaries, fifteen different mapping units related to minerals were develope (Table 8) for use across the state. Deep mines and strip mines were differentiated into active and inactive groups, while gas fields were divided into those under development, those inoperation, and those utilized for storage. All other mineral areas identified were considered to be at some level of production depending upon the geological, economic and social conditions within the area. These original maps were then converted for encoding purposes, by assigning number combinations to all of the symbols.

Again a four digit code was utilized. The first two digits were compo of the two digit county-number (1-24 including Baltimore City). The second t digits denote the formation type as described in Table 8 and remain the same for a given formation regardless of the county. In this way the same type of area or deposit can be traced through more than one county by checking the last 2 digits of the number. We are able to maintain the significance of the data regardless of the county of occurrance. Cross-reference to the engineering geology material can add information on the parent formation in whic the mineral occurs.

The body of Table 9 contains the formation number originally developed for the engineering geology section connected with the mineral commodity listed across the top. The county of occurrance is placed vertically along the left hand side; however, when using this table for any purpose, one must remember that formation numbers do not have inter-county significance.

Table 8

MAPPING UNITS FOR MINERALS IN MARYLAND

Item

Item Encoded	States	Symbol used for Base Map	Code Number
deep coal mine	inactive	red triangle	01
deep coal mine	active	black square	02
strip coal mine	inactive	red shaded area	03
strip coal mine	active	green shaded area	04
sand and/or gravel pit	active	black dot	05
stone quarry	active	black dot	06
greensand area	contingent upon conditions	area bordered in yellow	08
diatomite area	active pit	area bordered in blue	09
gas field	in operation	area bordered in purple	10
gas field	under development	area bordered in purple	11
gas field	used for storage	area bordered in purple	12
peat pit	contingent upon condition	black dot	13
*copper deposits	contingent upon conditions	area bordered in orange	14
gold deposits	contingent upon conditions	area bordered in pink	15

*(includes lead, zinc, chrome, iron and silver as accessory minerals)

TABLE 9

MINERAL COMMODITIES IN

MARYLAND COUNTIES, LOCATED BY FORMATION NUMBER

	County	Coal	Crushed Stone	Carbonates	Slate, Shale & Clay	Sand & Grave
01	Allegany	13,14,15	05	05	13,14,15	
02	Anne Arundel			03	02,03	
03	Baltimore		03,07,08,09, 11,12,13	03	15,16,17	14,17,18,19
05	Calvert				01,02	02
06	Caroline				01,02,03	01,02,03
07	Carroll		06,13	06,13	14,15	
08	Cecil		03,04,05		09,10,11,15	08-15
09	Charles				01	01,02,03
10	Dorchester				01,02	01,02
11	Frederick		05,14,15	05,14,15	14,17,18	
12	Garrett	06,07,08	04	04	06,07,08	
13	Harford		07,08,09	03	06,12	11,13,14,15
14	Howard		03,08,09,11,12	03	14	14
15	Kent				01-04	01-04
16	Montgomery		03,07,09,10		09,12,13	12,13
17	Prince George's				01,02,06	01,02,04,05, 07,10
18	Queen Anne's				01-03	01-03
19	St. Mary's				01-03	01-03
20	Somerset				01-02	01,02
21	Talbot				01,02,03	01,02,03
22	Washington		06,08,09, 10,11,16	06,08,09, 10,11,16	12,14,15, 18,20,21	
23	Wicomico				01,02,03	01,02,03
24	Worcester				01,02	01,02

Table 9 (con't)

	County	High Silica Sand	Serpentine	Copper	Gold	Peat	Gas	Greensand	Diatomite
01	Allegany	13					X		
02	Anne Arundel							X*	X*
03	Baltimore		08	X+					
05	Calvert								X*
06	Caroline								
07	Carroll		02	X+					
08	Cecil							X*	
09	Charles							X*	X*
10	Dorcester								
11	Frederick			X+					
12	Garrett	06				X	X		
13	Harford		07						
14	Howard								
15	Kent					X		X*	
16	Montgomery	07			X				
17	Prince George's							X*	X*
18	Queen Anne's							X*	
19	St. Mary's								
20	Somerset								
21	Talbot								
22	Washington	17							
23	Wicomico								
24	Worcester								

X Not restricted to formation boundaries, see mineral resource map for location and extent.

+ Copper may be associated with variable amounts of zinc, lead, iron, silver, gold and chrome within a district's boundaries.

* Areas mapped include outcrops and contiguous near surface deposits.

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Note: The Maryland Department of Geology, Mines, and Water Resources was renamed Maryland Geological Survey in 1964.

Map Numbers

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